

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF LAND MANAGEMENT

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# THE EPHEMERIS

1981

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Prepared by  
Nautical Almanac Office  
United States Naval Observatory

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1981

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
(BUREAU OF LAND MANAGEMENT)



EPHEMERIS OF THE SUN, POLARIS  
AND  
OTHER SELECTED STARS  
WITH COMPANION DATA AND TABLES

FOR THE YEAR

1981 x

A Supplement to the Manual of Instruction for the Survey of the Public Lands  
of the United States

SEVENTY-SECOND EDITION

Prepared by Nautical Almanac Office  
United States Naval Observatory



Bureau of Land Management  
Library  
Denver Service Center

UNITED STATES  
GOVERNMENT PRINTING OFFICE  
WASHINGTON (1980)

## PREFACE

The arrangement of the astronomical data herein conforms to the methods and examples for the determination of time, latitude, and azimuth, practiced by the cadastral engineers of the Bureau of Land Management. These practices are described in the Manual of Instructions for the Survey of the Public Lands of the United States.

The methods long in use have been developed for the best operation of the improved solar transit, in combination with observations on the sun, Polaris, and the brighter equatorial stars, for the determination and verification of time, latitude, and azimuth. In this practice, the data for the *sun* are required in terms of daily *apparent positions* for the Greenwich meridian; for all *stellar* positions in terms of the Greenwich meridian, *mean time*, and *mean time intervals*.

The apparent time of sunrise and of sunset, the refractions in polar distance, and the companion trigonometric tables and formulas employed in these methods, are tabulated in the Standard Field Tables of the Bureau of Land Management.

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### Other Technical Publications

The Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, has for sale to the public at current cost of printing the following technical publications of the Bureau of Land Management.

The Manual of Instructions for the Survey of the Public Lands of the United States, 1973.

Standard Field Tables, 1956 (a supplement to the Manual of Surveying Instructions); contains traverse tables; stadia coefficients; 5-place natural and 6-place logarithmic sines, cosines, tangents, and cotangents; 6-place logarithms of numbers; and other tables and data of particular application in land surveying practice.

The Ephemeris, published annually.

Restoration of Lost or Obliterated Corners and Subdivisions of Sections, 1963 edition, reprint 1965; a compendium of the rules that are applicable within the area of the United States rectangular surveys, for the guidance of county and other local surveyors, with explanation of the methods relating to retracements.

| AT GREENWICH APPARENT NOON |                         |                        |                        |                                                        |                                                    |                        | POLARIS FOR THE MERIDIAN<br>OF GREENWICH, CIVIL DATE<br>AND MEAN TIME |                                 |             |  |
|----------------------------|-------------------------|------------------------|------------------------|--------------------------------------------------------|----------------------------------------------------|------------------------|-----------------------------------------------------------------------|---------------------------------|-------------|--|
| Date                       | THE SUN'S               |                        |                        | Time<br>Semi-<br>diam-<br>eter<br>Pass-<br>ing<br>Mer. | Equation<br>of Time,<br>Add to<br>Apparent<br>Time | Upper Cul-<br>mination | Elongation<br>Lat. 40°                                                | Decli-<br>nation                |             |  |
|                            | Apparent<br>Declination | Diff.<br>for 1<br>Hour | Semi-<br>diam-<br>eter |                                                        |                                                    |                        |                                                                       |                                 |             |  |
| J A N U A R Y , 1 9 8 1    |                         |                        |                        |                                                        |                                                    |                        |                                                                       |                                 |             |  |
|                            |                         | ° ' "                  | "                      | ' "                                                    | s                                                  | m s                    | h m P.M.                                                              | W.E. h m A.M.                   | +89°<br>' " |  |
| Thur.                      | 1                       | S22 59 02.8            | +12.61                 | 16 17.49                                               | 71                                                 | 3 38.25                | 7 28.1 P.M.                                                           | 1 28.3 A.M.                     | 10 52.16    |  |
| Fri.                       | 2                       | 22 53 46.4             | 13.75                  | 16 17.49                                               | 71                                                 | 4 06.41                | 7 24.2                                                                | 1 24.4                          | 10 52.33    |  |
| Sat.                       | 3                       | 22 48 02.6             | 14.89                  | 16 17.48                                               | 71                                                 | 4 34.23                | 7 20.2                                                                | 1 20.4                          | 10 52.50    |  |
| Sun.                       | 4                       | 22 41 51.6             | 16.02                  | 16 17.47                                               | 71                                                 | 5 01.67                | 7 16.3                                                                | 1 16.5                          | 10 52.69    |  |
| Mon.                       | 5                       | 22 35 13.6             | 17.14                  | 16 17.46                                               | 71                                                 | 5 28.71                | 7 12.3                                                                | 1 12.5                          | 10 52.87    |  |
| Tues.                      | 6                       | 22 28 08.8             | 18.25                  | 16 17.45                                               | 71                                                 | 5 55.31                | 7 08.4                                                                | 1 08.6                          | 10 53.06    |  |
| Wed.                       | 7                       | 22 20 37.3             | 19.36                  | 16 17.43                                               | 71                                                 | 6 21.43                | 7 04.4                                                                | 1 04.6                          | 10 53.24    |  |
| Thur.                      | 8                       | 22 12 39.6             | 20.45                  | 16 17.40                                               | 71                                                 | 6 47.05                | 7 00.4                                                                | 1 00.7                          | 10 53.42    |  |
| Fri.                       | 9                       | 22 04 15.6             | 21.54                  | 16 17.38                                               | 71                                                 | 7 12.13                | 6 56.5                                                                | 0 56.7                          | 10 53.57    |  |
| Sat.                       | 10                      | 21 55 25.8             | 22.61                  | 16 17.35                                               | 70                                                 | 7 36.66                | 6 52.5                                                                | 0 52.8                          | 10 53.70    |  |
| Sun.                       | 11                      | 21 46 10.3             | 23.67                  | 16 17.31                                               | 70                                                 | 8 00.59                | 6 48.6                                                                | 0 48.8                          | 10 53.81    |  |
| Mon.                       | 12                      | 21 36 29.4             | 24.73                  | 16 17.27                                               | 70                                                 | 8 23.90                | 6 44.6                                                                | 0 44.8                          | 10 53.89    |  |
| Tues.                      | 13                      | 21 26 23.5             | 25.77                  | 16 17.23                                               | 70                                                 | 8 46.58                | 6 40.6                                                                | 0 40.9                          | 10 53.97    |  |
| Wed.                       | 14                      | 21 15 52.7             | 26.79                  | 16 17.18                                               | 70                                                 | 9 08.59                | 6 36.7                                                                | 0 36.9                          | 10 54.04    |  |
| Thur.                      | 15                      | 21 04 57.4             | 27.81                  | 16 17.13                                               | 70                                                 | 9 29.93                | 6 32.7                                                                | 0 33.0                          | 10 54.12    |  |
| Fri.                       | 16                      | 20 53 37.9             | 28.81                  | 16 17.07                                               | 70                                                 | 9 50.57                | 6 28.8                                                                | 0 29.0                          | 10 54.22    |  |
| Sat.                       | 17                      | 20 41 54.6             | 29.80                  | 16 17.00                                               | 70                                                 | 10 10.50               | 6 24.8                                                                | 0 25.1                          | 10 54.32    |  |
| Sun.                       | 18                      | 20 29 47.7             | 30.77                  | 16 16.93                                               | 70                                                 | 10 29.70               | 6 20.9                                                                | 0 21.1                          | 10 54.43    |  |
| Mon.                       | 19                      | 20 17 17.6             | 31.73                  | 16 16.85                                               | 70                                                 | 10 48.17               | 6 16.9                                                                | 0 17.2                          | 10 54.54    |  |
| Tues.                      | 20                      | 20 04 24.6             | 32.68                  | 16 16.77                                               | 70                                                 | 11 05.90               | 6 13.0                                                                | 0 13.2                          | 10 54.64    |  |
| Wed.                       | 21                      | 19 51 09.2             | 33.61                  | 16 16.68                                               | 69                                                 | 11 22.88               | 6 09.0                                                                | 0 09.2                          | 10 54.73    |  |
| Thur.                      | 22                      | 19 37 31.5             | 34.52                  | 16 16.58                                               | 69                                                 | 11 39.10               | 6 05.0                                                                | 0 05.3                          | 10 54.80    |  |
| Fri.                       | 23                      | 19 23 32.0             | 35.43                  | 16 16.48                                               | 69                                                 | 11 54.56               | 6 01.1                                                                | { 0 01.3 A.M.<br>11 57.4 P.M. } | 10 54.84    |  |
| Sat.                       | 24                      | 19 09 11.1             | 36.31                  | 16 16.37                                               | 69                                                 | 12 09.24               | 5 57.1                                                                | 11 53.4                         | 10 54.87    |  |
| Sun.                       | 25                      | 18 54 29.0             | 37.19                  | 16 16.25                                               | 69                                                 | 12 23.15               | 5 53.2                                                                | 11 49.4                         | 10 54.88    |  |
| Mon.                       | 26                      | 18 39 26.1             | 38.04                  | 16 16.14                                               | 69                                                 | 12 36.28               | 5 49.2                                                                | 11 45.5                         | 10 54.87    |  |
| Tues.                      | 27                      | 18 24 02.9             | 38.88                  | 16 16.01                                               | 69                                                 | 12 48.62               | 5 45.3                                                                | 11 41.5                         | 10 54.86    |  |
| Wed.                       | 28                      | 18 08 19.7             | 39.71                  | 16 15.88                                               | 69                                                 | 13 00.17               | 5 41.3                                                                | 11 37.6                         | 10 54.85    |  |
| Thur.                      | 29                      | 17 52 16.8             | 40.52                  | 16 15.75                                               | 69                                                 | 13 10.93               | 5 37.3                                                                | 11 33.6                         | 10 54.84    |  |
| Fri.                       | 30                      | 17 35 54.8             | 41.31                  | 16 15.61                                               | 68                                                 | 13 20.89               | 5 33.4                                                                | 11 29.7                         | 10 54.83    |  |
| Sat.                       | 31                      | S17 19 14.0            | +42.09                 | 16 15.47                                               | 68                                                 | 13 30.05               | 5 29.4 P.M.                                                           | W.E. 11 25.7 P.M.               | 10 54.83    |  |
| F E B R U A R Y , 1 9 8 1  |                         |                        |                        |                                                        |                                                    |                        |                                                                       |                                 |             |  |
| Sun.                       | 1                       | S17 02 14.7            | +42.84                 | 16 15.33                                               | 68                                                 | 13 38.40               | 5 25.5 P.M.                                                           | W.E. 11 21.8 P.M.               | 10 54.84    |  |
| Mon.                       | 2                       | 16 44 57.5             | 43.58                  | 16 15.18                                               | 68                                                 | 13 45.95               | 5 21.5                                                                | 11 17.8                         | 10 54.85    |  |
| Tues.                      | 3                       | 16 27 22.7             | 44.31                  | 16 15.03                                               | 68                                                 | 13 52.69               | 5 17.6                                                                | 11 13.8                         | 10 54.86    |  |
| Wed.                       | 4                       | 16 09 30.7             | 45.01                  | 16 14.87                                               | 68                                                 | 13 58.62               | 5 13.6                                                                | 11 09.9                         | 10 54.86    |  |
| Thur.                      | 5                       | 15 51 22.0             | 45.70                  | 16 14.72                                               | 68                                                 | 14 03.75               | 5 09.6                                                                | 11 05.9                         | 10 54.85    |  |
| Fri.                       | 6                       | 15 32 57.0             | 46.37                  | 16 14.56                                               | 68                                                 | 14 08.06               | 5 05.7                                                                | 11 02.0                         | 10 54.81    |  |
| Sat.                       | 7                       | 15 14 16.1             | 47.03                  | 16 14.40                                               | 68                                                 | 14 11.56               | 5 01.7                                                                | 10 58.0                         | 10 54.74    |  |
| Sun.                       | 8                       | 14 55 19.8             | 47.66                  | 16 14.23                                               | 67                                                 | 14 14.25               | 4 57.8                                                                | 10 54.0                         | 10 54.66    |  |
| Mon.                       | 9                       | 14 36 08.4             | 48.28                  | 16 14.06                                               | 67                                                 | 14 16.14               | 4 53.8                                                                | 10 50.1                         | 10 54.56    |  |
| Tues.                      | 10                      | 14 16 42.4             | 48.88                  | 16 13.89                                               | 67                                                 | 14 17.22               | 4 49.8                                                                | 10 46.1                         | 10 54.45    |  |
| Wed.                       | 11                      | 13 57 02.2             | 49.46                  | 16 13.72                                               | 67                                                 | 14 17.52               | 4 45.9                                                                | 10 42.2                         | 10 54.35    |  |
| Thur.                      | 12                      | 13 37 08.3             | 50.02                  | 16 13.54                                               | 67                                                 | 14 17.02               | 4 41.9                                                                | 10 38.2                         | 10 54.26    |  |
| Fri.                       | 13                      | 13 17 01.1             | 50.57                  | 16 13.36                                               | 67                                                 | 14 15.75               | 4 38.0                                                                | 10 34.3                         | 10 54.18    |  |
| Sat.                       | 14                      | 12 56 40.9             | 51.10                  | 16 13.17                                               | 67                                                 | 14 13.72               | 4 34.0                                                                | 10 30.3                         | 10 54.11    |  |
| Sun.                       | 15                      | 12 36 08.2             | 51.61                  | 16 12.98                                               | 67                                                 | 14 10.93               | 4 30.1                                                                | 10 26.4                         | 10 54.04    |  |
| Mon.                       | 16                      | S12 15 23.5            | +52.11                 | 16 12.79                                               | 67                                                 | 14 07.42               | 4 26.1 P.M.                                                           | W.E. 10 22.4 P.M.               | 10 53.96    |  |

The sign + prefixed to the hourly change of declination indicates that { north } declinations are { increasing.  
south } decreasing.

| AT GREENWICH APPARENT NOON |                         |                        |                        |                                                        |                                                    |                        | POLARIS FOR THE MERIDIAN<br>OF GREENWICH, CIVIL DATE<br>AND MEAN TIME |                  |             |  |
|----------------------------|-------------------------|------------------------|------------------------|--------------------------------------------------------|----------------------------------------------------|------------------------|-----------------------------------------------------------------------|------------------|-------------|--|
| Date                       | THE SUN'S               |                        |                        | Time<br>Semi-<br>diam-<br>eter<br>Pass-<br>ing<br>Mer. | Equation<br>of Time,<br>Add to<br>Apparent<br>Time | Upper Cul-<br>mination | Elongation<br>Lat. 40°                                                | Decli-<br>nation |             |  |
|                            | Apparent<br>Declination | Diff.<br>for 1<br>Hour | Semi-<br>diam-<br>eter |                                                        |                                                    |                        |                                                                       |                  |             |  |
| F E B R U A R Y , 1 9 8 1  |                         |                        |                        |                                                        |                                                    |                        |                                                                       |                  |             |  |
|                            |                         | ° ' "                  | "                      | ' "                                                    | s                                                  | m s                    | h m                                                                   | h m              | +89°<br>' " |  |
| Mon. 16                    | S 12 15 23.5            | +52.11                 | 16 12.79               | 67                                                     | 14 07.42                                           | 4 26.1 P.M.            | W.E. 10 22.4 P.M.                                                     | 10 53.96         |             |  |
| Tues. 17                   | 11 54 27.1              | 52.58                  | 16 12.59               | 66                                                     | 14 03.18                                           | 4 22.2                 | 10 18.4                                                               | 10 53.88         |             |  |
| Wed. 18                    | 11 33 19.5              | 53.05                  | 16 12.38               | 66                                                     | 13 58.24                                           | 4 18.2                 | 10 14.5                                                               | 10 53.77         |             |  |
| Thur. 19                   | 11 12 01.0              | 53.49                  | 16 12.17               | 66                                                     | 13 52.62                                           | 4 14.3                 | 10 10.5                                                               | 10 53.65         |             |  |
| Fri. 20                    | 10 50 32.0              | 53.92                  | 16 11.96               | 66                                                     | 13 46.33                                           | 4 10.3                 | 10 06.6                                                               | 10 53.51         |             |  |
| Sat. 21                    | 10 28 52.9              | 54.33                  | 16 11.74               | 66                                                     | 13 39.39                                           | 4 06.3                 | 10 02.6                                                               | 10 53.35         |             |  |
| Sun. 22                    | 10 07 04.1              | 54.73                  | 16 11.52               | 66                                                     | 13 31.83                                           | 4 02.4                 | 9 58.7                                                                | 10 53.18         |             |  |
| Mon. 23                    | 9 45 06.0               | 55.11                  | 16 11.29               | 66                                                     | 13 23.65                                           | 3 58.4                 | 9 54.7                                                                | 10 52.99         |             |  |
| Tues. 24                   | 9 22 59.0               | 55.47                  | 16 11.06               | 66                                                     | 13 14.88                                           | 3 54.5                 | 9 50.8                                                                | 10 52.81         |             |  |
| Wed. 25                    | 9 00 43.5               | 55.82                  | 16 10.83               | 66                                                     | 13 05.53                                           | 3 50.5                 | 9 46.8                                                                | 10 52.63         |             |  |
| Thur. 26                   | 8 38 19.9               | 56.15                  | 16 10.59               | 66                                                     | 12 55.63                                           | 3 46.6                 | 9 42.8                                                                | 10 52.45         |             |  |
| Fri. 27                    | 8 15 48.5               | 56.46                  | 16 10.36               | 66                                                     | 12 45.18                                           | 3 42.6                 | 9 38.9                                                                | 10 52.28         |             |  |
| Sat. 28                    | S 7 53 09.8             | +56.76                 | 16 10.11               | 65                                                     | 12 34.22                                           | 3 38.7 P.M.            | W.E. 9 34.9 P.M.                                                      | 10 52.11         |             |  |
| M A R C H , 1 9 8 1        |                         |                        |                        |                                                        |                                                    |                        |                                                                       |                  |             |  |
| Sun. 1                     | S 7 30 24.1             | +57.04                 | 16 09.87               | 65                                                     | 12 22.75                                           | 3 34.7 P.M.            | W.E. 9 31.0 P.M.                                                      | 10 51.95         |             |  |
| Mon. 2                     | 7 07 31.9               | 57.30                  | 16 09.63               | 65                                                     | 12 10.79                                           | 3 30.8                 | 9 27.0                                                                | 10 51.80         |             |  |
| Tues. 3                    | 6 44 33.6               | 57.55                  | 16 09.38               | 65                                                     | 11 58.36                                           | 3 26.8                 | 9 23.1                                                                | 10 51.64         |             |  |
| Wed. 4                     | 6 21 29.6               | 57.78                  | 16 09.13               | 65                                                     | 11 45.47                                           | 3 22.9                 | 9 19.1                                                                | 10 51.47         |             |  |
| Thur. 5                    | 5 58 20.2               | 57.99                  | 16 08.88               | 65                                                     | 11 32.14                                           | 3 18.9                 | 9 15.2                                                                | 10 51.28         |             |  |
| Fri. 6                     | 5 35 05.9               | 58.19                  | 16 08.63               | 65                                                     | 11 18.39                                           | 3 14.9                 | 9 11.2                                                                | 10 51.07         |             |  |
| Sat. 7                     | 5 11 47.1               | 58.37                  | 16 08.38               | 65                                                     | 11 04.23                                           | 3 11.0                 | 9 07.3                                                                | 10 50.84         |             |  |
| Sun. 8                     | 4 48 24.2               | 58.53                  | 16 08.13               | 65                                                     | 10 49.67                                           | 3 07.0                 | 9 03.3                                                                | 10 50.59         |             |  |
| Mon. 9                     | 4 24 57.6               | 58.68                  | 16 07.88               | 65                                                     | 10 34.73                                           | 3 03.1                 | 8 59.4                                                                | 10 50.33         |             |  |
| Tues. 10                   | 4 01 27.6               | 58.81                  | 16 07.62               | 65                                                     | 10 19.43                                           | 2 59.1                 | 8 55.4                                                                | 10 50.08         |             |  |
| Wed. 11                    | 3 37 54.8               | 58.92                  | 16 07.37               | 65                                                     | 10 03.78                                           | 2 55.2                 | 8 51.5                                                                | 10 49.84         |             |  |
| Thur. 12                   | 3 14 19.4               | 59.02                  | 16 07.12               | 65                                                     | 9 47.80                                            | 2 51.3                 | 8 47.5                                                                | 10 49.61         |             |  |
| Fri. 13                    | 2 50 41.9               | 59.10                  | 16 06.86               | 65                                                     | 9 31.51                                            | 2 47.3                 | 8 43.6                                                                | 10 49.39         |             |  |
| Sat. 14                    | 2 27 02.7               | 59.16                  | 16 06.60               | 65                                                     | 9 14.93                                            | 2 43.4                 | 8 39.6                                                                | 10 49.18         |             |  |
| Sun. 15                    | 2 03 22.1               | 59.21                  | 16 06.34               | 65                                                     | 8 58.08                                            | 2 39.4                 | 8 35.7                                                                | 10 48.97         |             |  |
| Mon. 16                    | 1 39 40.5               | 59.25                  | 16 06.08               | 65                                                     | 8 40.98                                            | 2 35.5                 | 8 31.7                                                                | 10 48.75         |             |  |
| Tues. 17                   | 1 15 58.2               | 59.27                  | 16 05.82               | 65                                                     | 8 23.66                                            | 2 31.5                 | 8 27.8                                                                | 10 48.51         |             |  |
| Wed. 18                    | 0 52 15.7               | 59.27                  | 16 05.55               | 65                                                     | 8 06.15                                            | 2 27.6                 | 8 23.8                                                                | 10 48.27         |             |  |
| Thur. 19                   | 0 28 33.3               | 59.26                  | 16 05.29               | 65                                                     | 7 48.46                                            | 2 23.6                 | 8 19.9                                                                | 10 48.00         |             |  |
| Fri. 20                    | S 0 04 51.3             | 59.24                  | 16 05.01               | 65                                                     | 7 30.61                                            | 2 19.7                 | 8 15.9                                                                | 10 47.72         |             |  |
| Sat. 21                    | N 0 18 50.0             | 59.20                  | 16 04.74               | 64                                                     | 7 12.64                                            | 2 15.7                 | 8 12.0                                                                | 10 47.42         |             |  |
| Sun. 22                    | 0 42 30.2               | 59.14                  | 16 04.47               | 64                                                     | 6 54.57                                            | 2 11.8                 | 8 08.1                                                                | 10 47.12         |             |  |
| Mon. 23                    | 1 06 09.0               | 59.08                  | 16 04.19               | 64                                                     | 6 36.42                                            | 2 07.8                 | 8 04.1                                                                | 10 46.82         |             |  |
| Tues. 24                   | 1 29 45.9               | 59.00                  | 16 03.91               | 64                                                     | 6 18.21                                            | 2 03.9                 | 8 00.2                                                                | 10 46.51         |             |  |
| Wed. 25                    | 1 53 20.8               | 58.90                  | 16 03.63               | 64                                                     | 5 59.97                                            | 1 60.0                 | 7 56.2                                                                | 10 46.22         |             |  |
| Thur. 26                   | 2 16 53.2               | 58.79                  | 16 03.35               | 64                                                     | 5 41.71                                            | 1 56.0                 | 7 52.3                                                                | 10 45.93         |             |  |
| Fri. 27                    | 2 40 22.9               | 58.67                  | 16 03.07               | 64                                                     | 5 23.47                                            | 1 52.1                 | 7 48.3                                                                | 10 45.66         |             |  |
| Sat. 28                    | 3 03 49.4               | 58.53                  | 16 02.79               | 64                                                     | 5 05.25                                            | 1 48.1                 | 7 44.4                                                                | 10 45.39         |             |  |
| Sun. 29                    | 3 27 12.4               | 58.38                  | 16 02.51               | 64                                                     | 4 47.08                                            | 1 44.2                 | 7 40.5                                                                | 10 45.13         |             |  |
| Mon. 30                    | 3 50 31.6               | 58.21                  | 16 02.22               | 64                                                     | 4 28.99                                            | 1 40.2                 | 7 36.5                                                                | 10 44.87         |             |  |
| Tues. 31                   | 4 13 46.6               | 58.03                  | 16 01.94               | 64                                                     | 4 10.98                                            | 1 36.3                 | 7 32.6                                                                | 10 44.61         |             |  |
| Wed. 32                    | N 4 36 57.0             | +57.83                 | 16 01.66               | 64                                                     | 3 53.09                                            | 1 32.4 P.M.            | W.E. 7 28.6 P.M.                                                      | 10 44.33         |             |  |

The sign + prefixed to the hourly change of declination indicates that { north } declinations are { increasing. }  
south } declinations are { decreasing. }

| AT GREENWICH APPARENT NOON |                         |                        |                        |                                                        |                                                                        | POLARIS FOR THE MERIDIAN<br>OF GREENWICH, CIVIL DATE<br>AND MEAN TIME |                        |                  |             |
|----------------------------|-------------------------|------------------------|------------------------|--------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------|------------------------|------------------|-------------|
| Date                       | THE SUN'S               |                        |                        | Time<br>Semi-<br>diam-<br>eter<br>Pass-<br>ing<br>Mer. | Equation<br>of Time,<br>Add to<br>Subtract<br>from<br>Apparent<br>Time | Upper Cul-<br>mination                                                | Elongation<br>Lat. 40° | Decli-<br>nation |             |
|                            | Apparent<br>Declination | Diff.<br>for 1<br>Hour | Semi-<br>diam-<br>eter |                                                        |                                                                        |                                                                       |                        |                  |             |
| A P R I L , 1 9 8 1        |                         |                        |                        |                                                        |                                                                        |                                                                       |                        |                  |             |
|                            |                         | ° ' "                  | "                      | ' "                                                    | s                                                                      | m s                                                                   | h m P.M.               | W.E. h m P.M.    | +89°<br>' " |
| Wed. 1                     | N 4 36 57.0             | +57.83                 | 16 01.66               | 64                                                     | 3 53.09                                                                | 1 32.4 P.M.                                                           | 7 28.6 P.M.            | 10 44.33         |             |
| Thur. 2                    | 5 00 02.6               | 57.62                  | 16 01.38               | 65                                                     | 3 35.31                                                                | 1 28.4                                                                | 7 24.7                 | 10 44.04         |             |
| Fri. 3                     | 5 23 02.9               | 57.40                  | 16 01.10               | 65                                                     | 3 17.68                                                                | 1 24.5                                                                | 7 20.7                 | 10 43.73         |             |
| Sat. 4                     | 5 45 57.6               | 57.15                  | 16 00.82               | 65                                                     | 3 00.21                                                                | 1 20.5                                                                | 7 16.8                 | 10 43.40         |             |
| Sun. 5                     | 6 08 46.3               | 56.90                  | 16 00.55               | 65                                                     | 2 42.90                                                                | 1 16.6                                                                | 7 12.9                 | 10 43.07         |             |
| Mon. 6                     | 6 31 28.6               | 56.62                  | 16 00.28               | 65                                                     | 2 25.78                                                                | 1 12.7                                                                | 7 08.9                 | 10 42.73         |             |
| Tues. 7                    | 6 54 04.2               | 56.34                  | 16 00.00               | 65                                                     | 2 08.86                                                                | 1 08.7                                                                | 7 05.0                 | 10 42.41         |             |
| Wed. 8                     | 7 16 32.8               | 56.03                  | 15 59.73               | 65                                                     | 1 52.14                                                                | 1 04.8                                                                | 7 01.1                 | 10 42.10         |             |
| Thur. 9                    | 7 38 53.9               | 55.72                  | 15 59.47               | 65                                                     | 1 35.65                                                                | 1 00.9                                                                | 6 57.1                 | 10 41.81         |             |
| Fri. 10                    | 8 01 07.2               | 55.38                  | 15 59.20               | 65                                                     | 1 19.40                                                                | 12 56.9                                                               | 6 53.2                 | 10 41.53         |             |
| Sat. 11                    | 8 23 12.4               | 55.04                  | 15 58.93               | 65                                                     | 1 03.40                                                                | 12 53.0                                                               | 6 49.2                 | 10 41.26         |             |
| Sun. 12                    | 8 45 09.0               | 54.67                  | 15 58.67               | 65                                                     | 0 47.67                                                                | 12 49.0                                                               | 6 45.3                 | 10 40.99         |             |
| Mon. 13                    | 9 06 56.7               | 54.30                  | 15 58.40               | 65                                                     | 0 32.23                                                                | 12 45.1                                                               | 6 41.4                 | 10 40.71         |             |
| Tues. 14                   | 9 28 35.3               | 53.91                  | 15 58.14               | 65                                                     | 0 17.10                                                                | 12 41.2                                                               | 6 37.4                 | 10 40.41         |             |
| Wed. 15                    | 9 50 04.3               | 53.50                  | 15 57.88               | 65                                                     | 0 02.30                                                                | 12 37.2                                                               | 6 33.5                 | 10 40.10         |             |
| Thur. 16                   | 10 11 23.5              | 53.09                  | 15 57.61               | 65                                                     | 0 12.16                                                                | 12 33.3                                                               | 6 29.6                 | 10 39.77         |             |
| Fri. 17                    | 10 32 32.6              | 52.66                  | 15 57.35               | 65                                                     | 0 26.26                                                                | 12 29.4                                                               | 6 25.6                 | 10 39.44         |             |
| Sat. 18                    | 10 53 31.1              | 52.22                  | 15 57.09               | 65                                                     | 0 39.98                                                                | 12 25.4                                                               | 6 21.7                 | 10 39.10         |             |
| Sun. 19                    | 11 14 18.9              | 51.76                  | 15 56.82               | 65                                                     | 0 53.30                                                                | 12 21.5                                                               | 6 17.8                 | 10 38.76         |             |
| Mon. 20                    | 11 34 55.6              | 51.29                  | 15 56.56               | 65                                                     | 1 06.21                                                                | 12 17.6                                                               | 6 13.8                 | 10 38.42         |             |
| Tues. 21                   | 11 55 20.8              | 50.81                  | 15 56.30               | 65                                                     | 1 18.68                                                                | 12 13.6                                                               | 6 09.9                 | 10 38.09         |             |
| Wed. 22                    | 12 15 34.4              | 50.31                  | 15 56.04               | 65                                                     | 1 30.71                                                                | 12 09.7                                                               | 6 06.0                 | 10 37.77         |             |
| Thur. 23                   | 12 35 35.9              | 49.81                  | 15 55.78               | 65                                                     | 1 42.29                                                                | 12 05.8                                                               | 6 02.0                 | 10 37.47         |             |
| Fri. 24                    | 12 55 25.0              | 49.28                  | 15 55.52               | 66                                                     | 1 53.38                                                                | 12 01.9 P.M.                                                          | W.E. 5 58.1 P.M.       | 10 37.18         |             |
| Sat. 25                    | 13 15 01.5              | 48.75                  | 15 55.26               | 66                                                     | 2 03.99                                                                | 11 57.9 A.M.                                                          | E.E. 6 01.7 A.M.       | 10 36.90         |             |
| Sun. 26                    | 13 34 25.0              | 48.20                  | 15 55.00               | 66                                                     | 2 14.10                                                                | 11 54.0                                                               | 5 57.7                 | 10 36.62         |             |
| Mon. 27                    | 13 53 35.3              | 47.64                  | 15 54.75               | 66                                                     | 2 23.70                                                                | 11 50.1                                                               | 5 53.8                 | 10 36.35         |             |
| Tues. 28                   | 14 12 31.9              | 47.07                  | 15 54.50               | 66                                                     | 2 32.77                                                                | 11 46.1                                                               | 5 49.9                 | 10 36.07         |             |
| Wed. 29                    | 14 31 14.5              | 46.48                  | 15 54.24               | 66                                                     | 2 41.31                                                                | 11 42.2                                                               | 5 45.9                 | 10 35.78         |             |
| Thur. 30                   | N14 49 42.9             | +45.88                 | 15 54.00               | 66                                                     | 2 49.31                                                                | 11 38.3 A.M.                                                          | E.E. 5 42.0 A.M.       | 10 35.48         |             |
| M A Y , 1 9 8 1            |                         |                        |                        |                                                        |                                                                        |                                                                       |                        |                  |             |
| Fri. 1                     | N15 07 56.7             | +45.26                 | 15 53.75               | 66                                                     | 2 56.77                                                                | 11 34.4 A.M.                                                          | E.E. 5 38.1 A.M.       | 10 35.16         |             |
| Sat. 2                     | 15 25 55.5              | 44.64                  | 15 53.51               | 66                                                     | 3 03.67                                                                | 11 30.4                                                               | 5 34.2                 | 10 34.83         |             |
| Sun. 3                     | 15 43 39.2              | 43.99                  | 15 53.27               | 66                                                     | 3 10.01                                                                | 11 26.5                                                               | 5 30.2                 | 10 34.50         |             |
| Mon. 4                     | 16 01 07.2              | 43.34                  | 15 53.04               | 66                                                     | 3 15.81                                                                | 11 22.6                                                               | 5 26.3                 | 10 34.18         |             |
| Tues. 5                    | 16 18 19.3              | 42.67                  | 15 52.81               | 66                                                     | 3 21.04                                                                | 11 18.7                                                               | 5 22.4                 | 10 33.88         |             |
| Wed. 6                     | 16 35 15.2              | 41.98                  | 15 52.58               | 66                                                     | 3 25.73                                                                | 11 14.7                                                               | 5 18.5                 | 10 33.60         |             |
| Thur. 7                    | 16 51 54.6              | 41.29                  | 15 52.36               | 67                                                     | 3 29.86                                                                | 11 10.8                                                               | 5 14.6                 | 10 33.34         |             |
| Fri. 8                     | 17 08 17.0              | 40.58                  | 15 52.14               | 67                                                     | 3 33.44                                                                | 11 06.9                                                               | 5 10.6                 | 10 33.10         |             |
| Sat. 9                     | 17 24 22.2              | 39.85                  | 15 51.93               | 67                                                     | 3 36.47                                                                | 11 03.0                                                               | 5 06.7                 | 10 32.85         |             |
| Sun. 10                    | 17 40 09.9              | 39.12                  | 15 51.72               | 67                                                     | 3 38.95                                                                | 10 59.0                                                               | 5 02.8                 | 10 32.61         |             |
| Mon. 11                    | 17 55 39.8              | 38.37                  | 15 51.51               | 67                                                     | 3 40.88                                                                | 10 55.1                                                               | 4 58.9                 | 10 32.35         |             |
| Tues. 12                   | 18 10 51.5              | 37.60                  | 15 51.31               | 67                                                     | 3 42.25                                                                | 10 51.2                                                               | 4 54.9                 | 10 32.08         |             |
| Wed. 13                    | 18 25 44.8              | 36.83                  | 15 51.10               | 67                                                     | 3 43.06                                                                | 10 47.3                                                               | 4 51.0                 | 10 31.80         |             |
| Thur. 14                   | 18 40 19.4              | 36.05                  | 15 50.90               | 67                                                     | 3 43.32                                                                | 10 43.3                                                               | 4 47.1                 | 10 31.50         |             |
| Fri. 15                    | 18 54 35.1              | 35.25                  | 15 50.70               | 67                                                     | 3 43.03                                                                | 10 39.4                                                               | 4 43.2                 | 10 31.21         |             |
| Sat. 16                    | N19 08 31.5             | +34.44                 | 15 50.51               | 67                                                     | 3 42.17                                                                | 10 35.5 A.M.                                                          | E.E. 4 39.3 A.M.       | 10 30.91         |             |

The sign + prefixed to the hourly change of declination indicates that { north } declinations are { increasing. }  
south } declinations are { decreasing. }

For time of Western Elongation of Polaris for any date after April 24th, add 5<sup>h</sup> 56.3<sup>m</sup> to the time of Upper Culmination of the same date.

| AT GREENWICH APPARENT NOON |                         |                        |                        |                                                        |                                                                        | POLARIS FOR THE MERIDIAN<br>OF GREENWICH, CIVIL DATE<br>AND MEAN TIME |                        |                  |  |
|----------------------------|-------------------------|------------------------|------------------------|--------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------|------------------------|------------------|--|
| Date                       | THE SUN'S               |                        |                        | Time<br>Semi-<br>diam-<br>eter<br>Pass-<br>ing<br>Mer. | Equation<br>of Time,<br>Subtract<br>from<br>Add to<br>Apparent<br>Time | Upper Cul-<br>mination                                                | Elongation<br>Lat. 40° | Decli-<br>nation |  |
|                            | Apparent<br>Declination | Diff.<br>for 1<br>Hour | Semi-<br>diam-<br>eter |                                                        |                                                                        |                                                                       |                        |                  |  |
| M A Y , 1 9 8 1            |                         |                        |                        |                                                        |                                                                        |                                                                       |                        |                  |  |
| Sat. 16                    | N19 08 31.5             | +34.44                 | 15 50.51               | 67                                                     | 3 42.17                                                                | 10 35.5 A.M.                                                          | E.E. 4 39.3 A.M.       | 10 30.91         |  |
| Sun. 17                    | 19 22 08.4              | 33.63                  | 15 50.31               | 67                                                     | 3 40.76                                                                | 10 31.6                                                               | 4 35.3                 | 10 30.62         |  |
| Mon. 18                    | 19 35 25.6              | 32.80                  | 15 50.12               | 67                                                     | 3 38.80                                                                | 10 27.7                                                               | 4 31.4                 | 10 30.34         |  |
| Tues. 19                   | 19 48 22.8              | 31.96                  | 15 49.93               | 67                                                     | 3 36.29                                                                | 10 23.8                                                               | 4 27.5                 | 10 30.08         |  |
| Wed. 20                    | 20 00 59.8              | 31.11                  | 15 49.74               | 68                                                     | 3 33.23                                                                | 10 19.8                                                               | 4 23.6                 | 10 29.83         |  |
| Thur. 21                   | 20 13 16.3              | 30.26                  | 15 49.56               | 68                                                     | 3 29.62                                                                | 10 15.9                                                               | 4 19.7                 | 10 29.59         |  |
| Fri. 22                    | 20 25 12.1              | 29.39                  | 15 49.38               | 68                                                     | 3 25.47                                                                | 10 12.0                                                               | 4 15.7                 | 10 29.37         |  |
| Sat. 23                    | 20 36 47.0              | 28.51                  | 15 49.19               | 68                                                     | 3 20.79                                                                | 10 08.1                                                               | 4 11.8                 | 10 29.16         |  |
| Sun. 24                    | 20 48 00.7              | 27.62                  | 15 49.02               | 68                                                     | 3 15.58                                                                | 10 04.2                                                               | 4 07.9                 | 10 28.95         |  |
| Mon. 25                    | 20 58 53.0              | 26.73                  | 15 48.84               | 68                                                     | 3 09.85                                                                | 10 00.2                                                               | 4 04.0                 | 10 28.74         |  |
| Tues. 26                   | 21 09 23.7              | 25.82                  | 15 48.67               | 68                                                     | 3 03.61                                                                | 9 56.3                                                                | 4 00.1                 | 10 28.53         |  |
| Wed. 27                    | 21 19 32.5              | 24.91                  | 15 48.50               | 68                                                     | 2 56.87                                                                | 9 52.4                                                                | 3 56.2                 | 10 28.31         |  |
| Thur. 28                   | 21 29 19.3              | 23.98                  | 15 48.34               | 68                                                     | 2 49.64                                                                | 9 48.5                                                                | 3 52.2                 | 10 28.07         |  |
| Fri. 29                    | 21 38 43.8              | 23.05                  | 15 48.18               | 68                                                     | 2 41.93                                                                | 9 44.6                                                                | 3 48.3                 | 10 27.83         |  |
| Sat. 30                    | 21 47 45.8              | 22.11                  | 15 48.02               | 68                                                     | 2 33.75                                                                | 9 40.7                                                                | 3 44.4                 | 10 27.58         |  |
| Sun. 31                    | N21 56 25.1             | +21.16                 | 15 47.87               | 68                                                     | 2 25.14                                                                | 9 36.7 A.M.                                                           | E.E. 3 40.5 A.M.       | 10 27.33         |  |
| J U N E , 1 9 8 1          |                         |                        |                        |                                                        |                                                                        |                                                                       |                        |                  |  |
| Mon. 1                     | N22 04 41.6             | +20.21                 | 15 47.73               | 68                                                     | 2 16.10                                                                | 9 32.8 A.M.                                                           | E.E. 3 36.6 A.M.       | 10 27.11         |  |
| Tues. 2                    | 22 12 35.0              | 19.24                  | 15 47.59               | 68                                                     | 2 06.66                                                                | 9 28.9                                                                | 3 32.7                 | 10 26.90         |  |
| Wed. 3                     | 22 20 05.2              | 18.27                  | 15 47.45               | 68                                                     | 1 56.84                                                                | 9 25.0                                                                | 3 28.8                 | 10 26.73         |  |
| Thur. 4                    | 22 27 12.0              | 17.29                  | 15 47.32               | 69                                                     | 1 46.67                                                                | 9 21.1                                                                | 3 24.9                 | 10 26.57         |  |
| Fri. 5                     | 22 33 55.3              | 16.31                  | 15 47.20               | 69                                                     | 1 36.16                                                                | 9 17.2                                                                | 3 20.9                 | 10 26.43         |  |
| Sat. 6                     | 22 40 14.7              | 15.31                  | 15 47.08               | 69                                                     | 1 25.35                                                                | 9 13.3                                                                | 3 17.0                 | 10 26.28         |  |
| Sun. 7                     | 22 46 10.3              | 14.32                  | 15 46.97               | 69                                                     | 1 14.25                                                                | 9 09.4                                                                | 3 13.1                 | 10 26.13         |  |
| Mon. 8                     | 22 51 41.9              | 13.31                  | 15 46.86               | 69                                                     | 1 02.89                                                                | 9 05.4                                                                | 3 09.2                 | 10 25.97         |  |
| Tues. 9                    | 22 56 49.2              | 12.30                  | 15 46.75               | 69                                                     | 0 51.28                                                                | 9 01.5                                                                | 3 05.3                 | 10 25.80         |  |
| Wed. 10                    | 23 01 32.4              | 11.29                  | 15 46.65               | 69                                                     | 0 39.44                                                                | 8 57.6                                                                | 3 01.4                 | 10 25.61         |  |
| Thur. 11                   | 23 05 51.1              | 10.27                  | 15 46.56               | 69                                                     | 0 27.40                                                                | 8 53.7                                                                | 2 57.5                 | 10 25.43         |  |
| Fri. 12                    | 23 09 45.4              | 9.25                   | 15 46.46               | 69                                                     | 0 15.18                                                                | 8 49.8                                                                | 2 53.5                 | 10 25.24         |  |
| Sat. 13                    | 23 13 15.1              | 8.23                   | 15 46.37               | 69                                                     | 0 02.79                                                                | 8 45.9                                                                | 2 49.6                 | 10 25.05         |  |
| Sun. 14                    | 23 16 20.3              | 7.20                   | 15 46.29               | 69                                                     | 0 09.74                                                                | 8 42.0                                                                | 2 45.7                 | 10 24.88         |  |
| Mon. 15                    | 23 19 00.8              | 6.17                   | 15 46.20               | 69                                                     | 0 22.39                                                                | 8 38.1                                                                | 2 41.8                 | 10 24.72         |  |
| Tues. 16                   | 23 21 16.6              | 5.14                   | 15 46.12               | 69                                                     | 0 35.15                                                                | 8 34.2                                                                | 2 37.9                 | 10 24.58         |  |
| Wed. 17                    | 23 23 07.7              | 4.11                   | 15 46.05               | 69                                                     | 0 47.98                                                                | 8 30.2                                                                | 2 34.0                 | 10 24.46         |  |
| Thur. 18                   | 23 24 34.1              | 3.08                   | 15 45.97               | 69                                                     | 1 00.89                                                                | 8 26.3                                                                | 2 30.1                 | 10 24.35         |  |
| Fri. 19                    | 23 25 35.7              | 2.05                   | 15 45.90               | 69                                                     | 1 13.83                                                                | 8 22.4                                                                | 2 26.2                 | 10 24.25         |  |
| Sat. 20                    | 23 26 12.5              | + 1.02                 | 15 45.83               | 69                                                     | 1 26.80                                                                | 8 18.5                                                                | 2 22.3                 | 10 24.17         |  |
| Sun. 21                    | 23 26 24.5              | - 0.02                 | 15 45.77               | 69                                                     | 1 39.77                                                                | 8 14.6                                                                | 2 18.4                 | 10 24.08         |  |
| Mon. 22                    | 23 26 11.7              | 1.05                   | 15 45.71               | 69                                                     | 1 52.72                                                                | 8 10.7                                                                | 2 14.4                 | 10 23.99         |  |
| Tues. 23                   | 23 25 34.2              | 2.08                   | 15 45.65               | 69                                                     | 2 05.64                                                                | 8 06.8                                                                | 2 10.5                 | 10 23.90         |  |
| Wed. 24                    | 23 24 31.9              | 3.11                   | 15 45.60               | 69                                                     | 2 18.49                                                                | 8 02.9                                                                | 2 06.6                 | 10 23.79         |  |
| Thur. 25                   | 23 23 04.8              | 4.14                   | 15 45.55               | 69                                                     | 2 31.27                                                                | 7 59.0                                                                | 2 02.7                 | 10 23.68         |  |
| Fri. 26                    | 23 21 13.1              | 5.17                   | 15 45.51               | 69                                                     | 2 43.94                                                                | 7 55.1                                                                | 1 58.8                 | 10 23.56         |  |
| Sat. 27                    | 23 18 56.8              | 6.19                   | 15 45.47               | 69                                                     | 2 56.49                                                                | 7 51.1                                                                | 1 54.9                 | 10 23.44         |  |
| Sun. 28                    | 23 16 15.8              | 7.22                   | 15 45.43               | 69                                                     | 3 08.89                                                                | 7 47.2                                                                | 1 51.0                 | 10 23.33         |  |
| Mon. 29                    | 23 13 10.4              | 8.23                   | 15 45.40               | 69                                                     | 3 21.12                                                                | 7 43.3                                                                | 1 47.1                 | 10 23.25         |  |
| Tues. 30                   | 23 09 40.6              | 9.25                   | 15 45.38               | 69                                                     | 3 33.14                                                                | 7 39.4                                                                | 1 43.2                 | 10 23.19         |  |
| Wed. 31                    | N23 05 46.4             | -10.26                 | 15 45.36               | 69                                                     | 3 44.93                                                                | 7 35.5 A.M.                                                           | E.E. 1 39.3 A.M.       | 10 23.16         |  |

The sign + prefixed to the hourly change of declination indicates that { north } declinations are { increasing. }  
south } decreasing.

The sign - prefixed to the hourly change of declination indicates that { south } declinations are { increasing. }  
north } decreasing.

| AT GREENWICH APPARENT NOON |                         |                        |                        |                                                        |                                                    |                        | POLARIS FOR THE MERIDIAN<br>OF GREENWICH, CIVIL DATE<br>AND MEAN TIME |                   |  |  |
|----------------------------|-------------------------|------------------------|------------------------|--------------------------------------------------------|----------------------------------------------------|------------------------|-----------------------------------------------------------------------|-------------------|--|--|
| Date                       | THE SUN'S               |                        |                        | Time<br>Semi-<br>diam-<br>eter<br>Pass-<br>ing<br>Mer. | Equation<br>of Time,<br>Add to<br>Apparent<br>Time | Upper Cul-<br>mination | Elongation<br>Lat. 40°                                                | Decli-<br>nation  |  |  |
|                            | Apparent<br>Declination | Diff.<br>for 1<br>Hour | Semi-<br>diam-<br>eter |                                                        |                                                    |                        |                                                                       |                   |  |  |
| J U L Y , 1 9 8 1          |                         |                        |                        |                                                        |                                                    |                        |                                                                       |                   |  |  |
| Wed. 1                     | ° ' " N23 05 46.4       | " -10.26               | ' " 15 45.36           | s 69                                                   | m s 3 44.93                                        | h m 7 35.5 A.M.        | E.E. h m 1 39.3 A.M.                                                  | ' " +89° 10 23.16 |  |  |
| Thur. 2                    | 23 01 28.0              | 11.27                  | 15 45.35               | 69                                                     | 3 56.46                                            | 7 31.6                 | 1 35.4                                                                | 10 23.15          |  |  |
| Fri. 3                     | 22 56 45.6              | 12.27                  | 15 45.35               | 69                                                     | 4 07.70                                            | 7 27.7                 | 1 31.5                                                                | 10 23.14          |  |  |
| Sat. 4                     | 22 51 39.1              | 13.27                  | 15 45.35               | 69                                                     | 4 18.63                                            | 7 23.8                 | 1 27.6                                                                | 10 23.13          |  |  |
| Sun. 5                     | 22 46 08.7              | 14.26                  | 15 45.35               | 69                                                     | 4 29.23                                            | 7 19.9                 | 1 23.6                                                                | 10 23.11          |  |  |
| Mon. 6                     | 22 40 14.6              | 15.25                  | 15 45.36               | 68                                                     | 4 39.46                                            | 7 16.0                 | 1 19.7                                                                | 10 23.08          |  |  |
| Tues. 7                    | 22 33 56.9              | 16.23                  | 15 45.38               | 68                                                     | 4 49.32                                            | 7 12.1                 | 1 15.8                                                                | 10 23.04          |  |  |
| Wed. 8                     | 22 27 15.7              | 17.20                  | 15 45.40               | 68                                                     | 4 58.79                                            | 7 08.2                 | 1 11.9                                                                | 10 23.00          |  |  |
| Thur. 9                    | 22 20 11.3              | 18.17                  | 15 45.43               | 68                                                     | 5 07.83                                            | 7 04.3                 | 1 08.0                                                                | 10 22.95          |  |  |
| Fri. 10                    | 22 12 43.7              | 19.13                  | 15 45.46               | 68                                                     | 5 16.44                                            | 7 00.4                 | 1 04.1                                                                | 10 22.90          |  |  |
| Sat. 11                    | 22 04 53.2              | 20.08                  | 15 45.49               | 68                                                     | 5 24.60                                            | 6 56.4                 | 1 00.2                                                                | 10 22.87          |  |  |
| Sun. 12                    | 21 56 40.0              | 21.02                  | 15 45.53               | 68                                                     | 5 32.30                                            | 6 52.5                 | 0 56.3                                                                | 10 22.84          |  |  |
| Mon. 13                    | 21 48 04.2              | 21.96                  | 15 45.57               | 68                                                     | 5 39.52                                            | 6 48.6                 | 0 52.4                                                                | 10 22.84          |  |  |
| Tues. 14                   | 21 39 06.0              | 22.88                  | 15 45.62               | 68                                                     | 5 46.25                                            | 6 44.7                 | 0 48.5                                                                | 10 22.85          |  |  |
| Wed. 15                    | 21 29 45.7              | 23.80                  | 15 45.66               | 68                                                     | 5 52.48                                            | 6 40.8                 | 0 44.6                                                                | 10 22.88          |  |  |
| Thur. 16                   | 21 20 03.5              | 24.71                  | 15 45.72               | 68                                                     | 5 58.20                                            | 6 36.9                 | 0 40.7                                                                | 10 22.92          |  |  |
| Fri. 17                    | 21 09 59.6              | 25.61                  | 15 45.77               | 68                                                     | 6 03.40                                            | 6 33.0                 | 0 36.8                                                                | 10 22.97          |  |  |
| Sat. 18                    | 20 59 34.3              | 26.50                  | 15 45.83               | 68                                                     | 6 08.07                                            | 6 29.1                 | 0 32.9                                                                | 10 23.03          |  |  |
| Sun. 19                    | 20 48 47.6              | 27.38                  | 15 45.89               | 68                                                     | 6 12.21                                            | 6 25.2                 | 0 29.0                                                                | 10 23.09          |  |  |
| Mon. 20                    | 20 37 39.9              | 28.25                  | 15 45.96               | 68                                                     | 6 15.81                                            | 6 21.3                 | 0 25.0                                                                | 10 23.14          |  |  |
| Tues. 21                   | 20 26 11.4              | 29.12                  | 15 46.02               | 67                                                     | 6 18.86                                            | 6 17.4                 | 0 21.1                                                                | 10 23.19          |  |  |
| Wed. 22                    | 20 14 22.3              | 29.97                  | 15 46.09               | 67                                                     | 6 21.36                                            | 6 13.5                 | 0 17.2                                                                | 10 23.22          |  |  |
| Thur. 23                   | 20 02 12.9              | 30.81                  | 15 46.17               | 67                                                     | 6 23.31                                            | 6 09.6                 | 0 13.3                                                                | 10 23.24          |  |  |
| Fri. 24                    | 19 49 43.3              | 31.64                  | 15 46.25               | 67                                                     | 6 24.70                                            | 6 05.7                 | 0 09.4                                                                | 10 23.27          |  |  |
| Sat. 25                    | 19 36 54.0              | 32.47                  | 15 46.33               | 67                                                     | 6 25.53                                            | 6 01.8                 | 0 05.5                                                                | 10 23.30          |  |  |
| Sun. 26                    | 19 23 45.0              | 33.28                  | 15 46.42               | 67                                                     | 6 25.78                                            | 5 57.9                 | { 0 01.6 A.M.<br>11 57.7 P.M. }                                       | 10 23.35          |  |  |
| Mon. 27                    | 19 10 16.7              | 34.08                  | 15 46.51               | 67                                                     | 6 25.46                                            | 5 54.0                 | 11 53.8                                                               | 10 23.43          |  |  |
| Tues. 28                   | 18 56 29.4              | 34.86                  | 15 46.61               | 67                                                     | 6 24.56                                            | 5 50.0                 | 11 49.9                                                               | 10 23.53          |  |  |
| Wed. 29                    | 18 42 23.3              | 35.64                  | 15 46.71               | 67                                                     | 6 23.06                                            | 5 46.1                 | 11 46.0                                                               | 10 23.65          |  |  |
| Thur. 30                   | 18 27 58.8              | 36.40                  | 15 46.82               | 67                                                     | 6 20.97                                            | 5 42.2                 | 11 42.1                                                               | 10 23.78          |  |  |
| Fri. 31                    | N18 13 16.1             | -37.15                 | 15 46.93               | 67                                                     | 6 18.27                                            | 5 38.3 A.M.            | E.E. 11 38.2 P.M.                                                     | 10 23.92          |  |  |
| A U G U S T , 1 9 8 1      |                         |                        |                        |                                                        |                                                    |                        |                                                                       |                   |  |  |
| Sat. 1                     | N17 58 15.5             | -37.89                 | 15 47.05               | 67                                                     | 6 14.96                                            | 5 34.4 A.M.            | E.E. 11 34.2 P.M.                                                     | 10 24.05          |  |  |
| Sun. 2                     | 17 42 57.4              | 38.62                  | 15 47.18               | 66                                                     | 6 11.04                                            | 5 30.5                 | 11 30.3                                                               | 10 24.17          |  |  |
| Mon. 3                     | 17 27 22.0              | 39.33                  | 15 47.31               | 66                                                     | 6 06.50                                            | 5 26.6                 | 11 26.4                                                               | 10 24.28          |  |  |
| Tues. 4                    | 17 11 29.6              | 40.03                  | 15 47.44               | 66                                                     | 6 01.35                                            | 5 22.7                 | 11 22.5                                                               | 10 24.38          |  |  |
| Wed. 5                     | 16 55 20.5              | 40.72                  | 15 47.58               | 66                                                     | 5 55.58                                            | 5 18.8                 | 11 18.6                                                               | 10 24.47          |  |  |
| Thur. 6                    | 16 38 55.1              | 41.40                  | 15 47.73               | 66                                                     | 5 49.19                                            | 5 14.9                 | 11 14.7                                                               | 10 24.57          |  |  |
| Fri. 7                     | 16 22 13.6              | 42.06                  | 15 47.87               | 66                                                     | 5 42.20                                            | 5 11.0                 | 11 10.8                                                               | 10 24.67          |  |  |
| Sat. 8                     | 16 05 16.3              | 42.71                  | 15 48.03               | 66                                                     | 5 34.59                                            | 5 07.1                 | 11 06.9                                                               | 10 24.78          |  |  |
| Sun. 9                     | 15 48 03.5              | 43.35                  | 15 48.18               | 66                                                     | 5 26.39                                            | 5 03.2                 | 11 03.0                                                               | 10 24.91          |  |  |
| Mon. 10                    | 15 30 35.7              | 43.97                  | 15 48.34               | 66                                                     | 5 17.59                                            | 4 59.3                 | 10 59.1                                                               | 10 25.06          |  |  |
| Tues. 11                   | 15 12 53.0              | 44.58                  | 15 48.50               | 66                                                     | 5 08.21                                            | 4 55.4                 | 10 55.2                                                               | 10 25.22          |  |  |
| Wed. 12                    | 14 54 55.8              | 45.18                  | 15 48.67               | 66                                                     | 4 58.24                                            | 4 51.5                 | 10 51.3                                                               | 10 25.40          |  |  |
| Thur. 13                   | 14 36 44.3              | 45.77                  | 15 48.84               | 66                                                     | 4 47.71                                            | 4 47.5                 | 10 47.4                                                               | 10 25.59          |  |  |
| Fri. 14                    | 14 18 19.0              | 46.34                  | 15 49.01               | 65                                                     | 4 36.63                                            | 4 43.6                 | 10 43.5                                                               | 10 25.79          |  |  |
| Sat. 15                    | 13 59 40.1              | 46.90                  | 15 49.18               | 65                                                     | 4 25.00                                            | 4 39.7                 | 10 39.5                                                               | 10 25.99          |  |  |
| Sun. 16                    | N13 40 47.9             | -47.45                 | 15 49.35               | 65                                                     | 4 12.84                                            | 4 35.8 A.M.            | E.E. 10 35.6 P.M.                                                     | 10 26.18          |  |  |

The sign - prefixed to the hourly change of declination indicates that { south } declinations are { increasing. }  
north { decreasing. }

The sign — prefixed to the hourly change of declination indicates that  $\begin{cases} \text{south} \\ \text{north} \end{cases}$  declinations are  $\begin{cases} \text{increasing.} \\ \text{decreasing.} \end{cases}$

The sign — prefixed to the hourly change of declination indicates that  $\begin{cases} \text{south} \\ \text{north} \end{cases}$  declinations are  $\begin{cases} \text{increasing.} \\ \text{decreasing.} \end{cases}$

| AT GREENWICH APPARENT NOON |                         |                        |                        |                                                        |                                                              |                        | POLARIS FOR THE MERIDIAN<br>OF GREENWICH, CIVIL DATE<br>AND MEAN TIME |                  |             |                         |
|----------------------------|-------------------------|------------------------|------------------------|--------------------------------------------------------|--------------------------------------------------------------|------------------------|-----------------------------------------------------------------------|------------------|-------------|-------------------------|
| Date                       | THE SUN'S               |                        |                        | Time<br>Semi-<br>diam-<br>eter<br>Pass-<br>ing<br>Mer. | Equation<br>of Time,<br>Subtract<br>from<br>Apparent<br>Time | Upper Cul-<br>mination | Elongation<br>Lat. 40°                                                | Decli-<br>nation |             |                         |
|                            | Apparent<br>Declination | Diff.<br>for 1<br>Hour | Semi-<br>diam-<br>eter |                                                        |                                                              |                        |                                                                       |                  |             |                         |
| OCTOBER, 1981              |                         |                        |                        |                                                        |                                                              |                        |                                                                       |                  |             |                         |
|                            |                         | ° ' "                  | "                      | ' "                                                    | s                                                            | m s                    | h m                                                                   |                  | h m         | +89°<br>' "             |
| Thur.                      | 1                       | S 3 15 22.9            | -58.19                 | 16 00.23                                               | 64                                                           | 10 19.99               | 1 35.9 A.M.                                                           | E.E.             | 7 35.7 P.M. | 10 38.51                |
| Fri.                       | 2                       | 3 38 38.3              | 58.09                  | 16 00.51                                               | 64                                                           | 10 39.04               | 1 31.9                                                                |                  | 7 31.7      | 10 38.83                |
| Sat.                       | 3                       | 4 01 51.2              | 57.98                  | 16 00.79                                               | 64                                                           | 10 57.80               | 1 28.0                                                                |                  | 7 27.8      | 10 39.16                |
| Sun.                       | 4                       | 4 25 01.2              | 57.85                  | 16 01.07                                               | 64                                                           | 11 16.24               | 1 24.1                                                                |                  | 7 23.9      | 10 39.51                |
| Mon.                       | 5                       | 4 48 07.9              | 57.71                  | 16 01.35                                               | 64                                                           | 11 34.34               | 1 20.2                                                                |                  | 7 20.0      | 10 39.87                |
| Tues.                      | 6                       | 5 11 11.0              | 57.55                  | 16 01.64                                               | 65                                                           | 11 52.08               | 1 16.3                                                                |                  | 7 16.1      | 10 40.25                |
| Wed.                       | 7                       | 5 34 10.1              | 57.37                  | 16 01.92                                               | 65                                                           | 12 09.45               | 1 12.3                                                                |                  | 7 12.2      | 10 40.63                |
| Thur.                      | 8                       | 5 57 04.9              | 57.18                  | 16 02.20                                               | 65                                                           | 12 26.43               | 1 08.4                                                                |                  | 7 08.2      | 10 41.02                |
| Fri.                       | 9                       | 6 19 54.8              | 56.98                  | 16 02.48                                               | 65                                                           | 12 42.99               | 1 04.5                                                                |                  | 7 04.3      | 10 41.40                |
| Sat.                       | 10                      | 6 42 39.7              | 56.75                  | 16 02.76                                               | 65                                                           | 12 59.12               | 1 00.6                                                                |                  | 7 00.4      | 10 41.78                |
| Sun.                       | 11                      | 7 05 19.0              | 56.52                  | 16 03.04                                               | 65                                                           | 13 14.79               | 0 56.7                                                                |                  | 6 56.5      | 10 42.14                |
| Mon.                       | 12                      | 7 27 52.6              | 56.27                  | 16 03.32                                               | 65                                                           | 13 29.98               | 0 52.7                                                                |                  | 6 52.5      | 10 42.49                |
| Tues.                      | 13                      | 7 50 19.9              | 56.00                  | 16 03.60                                               | 65                                                           | 13 44.67               | 0 48.8                                                                |                  | 6 48.6      | 10 42.83                |
| Wed.                       | 14                      | 8 12 40.8              | 55.72                  | 16 03.87                                               | 65                                                           | 13 58.83               | 0 44.9                                                                |                  | 6 44.7      | 10 43.16                |
| Thur.                      | 15                      | 8 34 54.7              | 55.43                  | 16 04.14                                               | 65                                                           | 14 12.44               | 0 41.0                                                                |                  | 6 40.8      | 10 43.49                |
| Fri.                       | 16                      | 8 57 01.5              | 55.12                  | 16 04.41                                               | 65                                                           | 14 25.48               | 0 37.0                                                                |                  | 6 36.8      | 10 43.84                |
| Sat.                       | 17                      | 9 19 00.7              | 54.80                  | 16 04.68                                               | 65                                                           | 14 37.92               | 0 33.1                                                                |                  | 6 32.9      | 10 44.21                |
| Sun.                       | 18                      | 9 40 52.0              | 54.46                  | 16 04.95                                               | 65                                                           | 14 49.75               | 0 29.2                                                                |                  | 6 29.0      | 10 44.60                |
| Mon.                       | 19                      | 10 02 34.9             | 54.11                  | 16 05.21                                               | 66                                                           | 15 00.95               | 0 25.3                                                                |                  | 6 25.1      | 10 45.01                |
| Tues.                      | 20                      | 10 24 09.2             | 53.74                  | 16 05.48                                               | 66                                                           | 15 11.51               | 0 21.4                                                                |                  | 6 21.2      | 10 45.42                |
| Wed.                       | 21                      | 10 45 34.4             | 53.35                  | 16 05.74                                               | 66                                                           | 15 21.39               | 0 17.4                                                                |                  | 6 17.2      | 10 45.83                |
| Thur.                      | 22                      | 11 06 50.1             | 52.95                  | 16 06.00                                               | 66                                                           | 15 30.60               | 0 13.5                                                                |                  | 6 13.3      | 10 46.23                |
| Fri.                       | 23                      | 11 27 55.9             | 52.53                  | 16 06.26                                               | 66                                                           | 15 39.12               | 0 09.6                                                                |                  | 6 09.4      | 10 46.62                |
| Sat.                       | 24                      | 11 48 51.4             | 52.09                  | 16 06.52                                               | 66                                                           | 15 46.93               | 0 05.6                                                                |                  | 6 05.4      | 10 47.00                |
| Sun.                       | 25                      | 12 09 36.2             | 51.64                  | 16 06.78                                               | 66                                                           | 15 54.02               | { 0 01.7 A.M.<br>11 57.8 P.M. }                                       | E.E.             | 6 01.5 P.M. | {10 47.35<br>10 47.70 } |
| Mon.                       | 26                      | 12 30 09.9             | 51.16                  | 16 07.04                                               | 66                                                           | 16 00.38               | 11 53.8                                                               | W.E.             | 5 54.1 A.M. | 10 48.05                |
| Tues.                      | 27                      | 12 50 32.1             | 50.67                  | 16 07.30                                               | 66                                                           | 16 06.01               | 11 49.9                                                               |                  | 5 50.1      | 10 48.39                |
| Wed.                       | 28                      | 13 10 42.3             | 50.17                  | 16 07.56                                               | 66                                                           | 16 10.89               | 11 46.0                                                               |                  | 5 46.2      | 10 48.74                |
| Thur.                      | 29                      | 13 30 40.1             | 49.64                  | 16 07.82                                               | 67                                                           | 16 15.01               | 11 42.1                                                               |                  | 5 42.3      | 10 49.11                |
| Fri.                       | 30                      | 13 50 25.2             | 49.10                  | 16 08.08                                               | 67                                                           | 16 18.37               | 11 38.1                                                               |                  | 5 38.3      | 10 49.48                |
| Sat.                       | 31                      | S14 09 57.1            | -48.54                 | 16 08.34                                               | 67                                                           | 16 20.96               | 11 34.2 P.M.                                                          | W.E.             | 5 34.4 A.M. | 10 49.86                |
| NOVEMBER, 1981             |                         |                        |                        |                                                        |                                                              |                        |                                                                       |                  |             |                         |
| Sun.                       | 1                       | S14 29 15.3            | -47.97                 | 16 08.60                                               | 67                                                           | 16 22.77               | 11 30.3 P.M.                                                          | W.E.             | 5 30.5 A.M. | 10 50.26                |
| Mon.                       | 2                       | 14 48 19.5             | 47.37                  | 16 08.85                                               | 67                                                           | 16 23.79               | 11 26.4                                                               |                  | 5 26.6      | 10 50.66                |
| Tues.                      | 3                       | 15 07 09.2             | 46.76                  | 16 09.10                                               | 67                                                           | 16 24.02               | 11 22.4                                                               |                  | 5 22.6      | 10 51.07                |
| Wed.                       | 4                       | 15 25 44.1             | 46.13                  | 16 09.36                                               | 67                                                           | 16 23.46               | 11 18.5                                                               |                  | 5 18.7      | 10 51.47                |
| Thur.                      | 5                       | 15 44 03.6             | 45.49                  | 16 09.61                                               | 67                                                           | 16 22.08               | 11 14.6                                                               |                  | 5 14.8      | 10 51.87                |
| Fri.                       | 6                       | 16 02 07.4             | 44.82                  | 16 09.85                                               | 67                                                           | 16 19.90               | 11 10.6                                                               |                  | 5 10.8      | 10 52.25                |
| Sat.                       | 7                       | 16 19 55.1             | 44.14                  | 16 10.10                                               | 68                                                           | 16 16.90               | 11 06.7                                                               |                  | 5 06.9      | 10 52.62                |
| Sun.                       | 8                       | 16 37 26.2             | 43.44                  | 16 10.34                                               | 68                                                           | 16 13.08               | 11 02.7                                                               |                  | 5 03.0      | 10 52.97                |
| Mon.                       | 9                       | 16 54 40.4             | 42.73                  | 16 10.57                                               | 68                                                           | 16 08.42               | 10 58.8                                                               |                  | 4 59.0      | 10 53.31                |
| Tues.                      | 10                      | 17 11 37.3             | 42.00                  | 16 10.81                                               | 68                                                           | 16 02.94               | 10 54.9                                                               |                  | 4 55.1      | 10 53.64                |
| Wed.                       | 11                      | 17 28 16.5             | 41.26                  | 16 11.04                                               | 68                                                           | 15 56.61               | 10 50.9                                                               |                  | 4 51.2      | 10 53.98                |
| Thur.                      | 12                      | 17 44 37.6             | 40.50                  | 16 11.26                                               | 68                                                           | 15 49.43               | 10 47.0                                                               |                  | 4 47.2      | 10 54.34                |
| Fri.                       | 13                      | 18 00 40.3             | 39.72                  | 16 11.48                                               | 68                                                           | 15 41.40               | 10 43.1                                                               |                  | 4 43.3      | 10 54.73                |
| Sat.                       | 14                      | 18 16 24.3             | 38.93                  | 16 11.70                                               | 68                                                           | 15 32.52               | 10 39.2                                                               |                  | 4 39.4      | 10 55.13                |
| Sun.                       | 15                      | 18 31 49.0             | 38.13                  | 16 11.91                                               | 69                                                           | 15 22.77               | 10 35.2                                                               |                  | 4 35.4      | 10 55.54                |
| Mon.                       | 16                      | S18 46 54.3            | -37.30                 | 16 12.12                                               | 69                                                           | 15 12.17               | 10 31.3 P.M.                                                          | W.E.             | 4 31.5 A.M. | 10 55.94                |

The sign - prefixed to the hourly change of declination indicates that { south } declinations are { increasing.  
north } decreasing.

For time of Eastern Elongation of Polaris for any date after October 25th, subtract 5<sup>h</sup> 56.3<sup>m</sup> from the time of Upper Culmination of the same date.

| AT GREENWICH APPARENT NOON |                         |                        |                        |                                                        |                                                                        |                        | POLARIS FOR THE MERIDIAN<br>OF GREENWICH, CIVIL DATE<br>AND MEAN TIME |                  |             |  |
|----------------------------|-------------------------|------------------------|------------------------|--------------------------------------------------------|------------------------------------------------------------------------|------------------------|-----------------------------------------------------------------------|------------------|-------------|--|
| Date                       | THE SUN'S               |                        |                        | Time<br>Semi-<br>diam-<br>eter<br>Pass-<br>ing<br>Mer. | Equation<br>of Time,<br>Subtract<br>from<br>Add to<br>Apparent<br>Time | Upper Cul-<br>mination | Elongation<br>Lat. 40°                                                | Decli-<br>nation |             |  |
|                            | Apparent<br>Declination | Diff.<br>for 1<br>Hour | Semi-<br>diam-<br>eter |                                                        |                                                                        |                        |                                                                       |                  |             |  |
| NOVEMBER, 1981             |                         |                        |                        |                                                        |                                                                        |                        |                                                                       |                  |             |  |
|                            |                         | ° ' "                  | "                      | ' "                                                    | s                                                                      | m s                    | h m P.M.                                                              | W.E. h m A.M.    | +89°<br>' " |  |
| Mon. 16                    | S18 46 54.3             | -37.30                 | 16 12.12               | 69                                                     | 15 12.17                                                               | 10 31.3 P.M.           | 4 31.5 A.M.                                                           | 10 55.94         |             |  |
| Tues. 17                   | 19 01 39.6              | 36.47                  | 16 12.32               | 69                                                     | 15 00.71                                                               | 10 27.3                | 4 27.6                                                                | 10 56.34         |             |  |
| Wed. 18                    | 19 16 04.6              | 35.61                  | 16 12.52               | 69                                                     | 14 48.40                                                               | 10 23.4                | 4 23.6                                                                | 10 56.72         |             |  |
| Thur. 19                   | 19 30 09.0              | 34.74                  | 16 12.72               | 69                                                     | 14 35.24                                                               | 10 19.5                | 4 19.7                                                                | 10 57.08         |             |  |
| Fri. 20                    | 19 43 52.2              | 33.86                  | 16 12.91               | 69                                                     | 14 21.23                                                               | 10 15.5                | 4 15.7                                                                | 10 57.43         |             |  |
| Sat. 21                    | 19 57 14.1              | 32.96                  | 16 13.10               | 69                                                     | 14 06.40                                                               | 10 11.6                | 4 11.8                                                                | 10 57.76         |             |  |
| Sun. 22                    | 20 10 14.1              | 32.04                  | 16 13.29               | 69                                                     | 13 50.75                                                               | 10 07.6                | 4 07.9                                                                | 10 58.08         |             |  |
| Mon. 23                    | 20 22 52.0              | 31.11                  | 16 13.48               | 69                                                     | 13 34.30                                                               | 10 03.7                | 4 03.9                                                                | 10 58.40         |             |  |
| Tues. 24                   | 20 35 07.3              | 30.16                  | 16 13.66               | 70                                                     | 13 17.06                                                               | 9 59.8                 | 3 60.0                                                                | 10 58.71         |             |  |
| Wed. 25                    | 20 46 59.8              | 29.20                  | 16 13.84               | 70                                                     | 12 59.04                                                               | 9 55.8                 | 3 56.0                                                                | 10 59.04         |             |  |
| Thur. 26                   | 20 58 29.0              | 28.23                  | 16 14.01               | 70                                                     | 12 40.27                                                               | 9 51.9                 | 3 52.1                                                                | 10 59.37         |             |  |
| Fri. 27                    | 21 09 34.7              | 27.24                  | 16 14.19               | 70                                                     | 12 20.76                                                               | 9 47.9                 | 3 48.2                                                                | 10 59.72         |             |  |
| Sat. 28                    | 21 20 16.5              | 26.24                  | 16 14.36               | 70                                                     | 12 00.53                                                               | 9 44.0                 | 3 44.2                                                                | 11 00.07         |             |  |
| Sun. 29                    | 21 30 34.0              | 25.22                  | 16 14.53               | 70                                                     | 11 39.61                                                               | 9 40.1                 | 3 40.3                                                                | 11 00.43         |             |  |
| Mon. 30                    | S21 40 27.0             | -24.19                 | 16 14.69               | 70                                                     | 11 18.02                                                               | 9 36.1 P.M.            | W.E. 3 36.3 A.M.                                                      | 11 00.79         |             |  |
| DECEMBER, 1981             |                         |                        |                        |                                                        |                                                                        |                        |                                                                       |                  |             |  |
| Tues. 1                    | S21 49 55.2             | -23.15                 | 16 14.86               | 70                                                     | 10 55.78                                                               | 9 32.2 P.M.            | W.E. 3 32.4 A.M.                                                      | 11 01.14         |             |  |
| Wed. 2                     | 21 58 58.2              | 22.10                  | 16 15.02               | 70                                                     | 10 32.91                                                               | 9 28.2                 | 3 28.5                                                                | 11 01.49         |             |  |
| Thur. 3                    | 22 07 35.8              | 21.03                  | 16 15.17               | 70                                                     | 10 09.43                                                               | 9 24.3                 | 3 24.5                                                                | 11 01.82         |             |  |
| Fri. 4                     | 22 15 47.7              | 19.95                  | 16 15.32               | 70                                                     | 9 45.39                                                                | 9 20.3                 | 3 20.6                                                                | 11 02.14         |             |  |
| Sat. 5                     | 22 23 33.6              | 18.87                  | 16 15.47               | 71                                                     | 9 20.79                                                                | 9 16.4                 | 3 16.6                                                                | 11 02.44         |             |  |
| Sun. 6                     | 22 30 53.3              | 17.77                  | 16 15.61               | 71                                                     | 8 55.66                                                                | 9 12.4                 | 3 12.7                                                                | 11 02.72         |             |  |
| Mon. 7                     | 22 37 46.5              | 16.66                  | 16 15.75               | 71                                                     | 8 30.03                                                                | 9 08.5                 | 3 08.7                                                                | 11 02.99         |             |  |
| Tues. 8                    | 22 44 13.1              | 15.55                  | 16 15.88               | 71                                                     | 8 03.92                                                                | 9 04.6                 | 3 04.8                                                                | 11 03.27         |             |  |
| Wed. 9                     | 22 50 12.8              | 14.43                  | 16 16.01               | 71                                                     | 7 37.37                                                                | 9 00.6                 | 3 00.8                                                                | 11 03.55         |             |  |
| Thur. 10                   | 22 55 45.5              | 13.30                  | 16 16.13               | 71                                                     | 7 10.38                                                                | 8 56.7                 | 2 56.9                                                                | 11 03.84         |             |  |
| Fri. 11                    | 23 00 51.0              | 12.16                  | 16 16.25               | 71                                                     | 6 42.99                                                                | 8 52.7                 | 2 53.0                                                                | 11 04.16         |             |  |
| Sat. 12                    | 23 05 29.2              | 11.02                  | 16 16.36               | 71                                                     | 6 15.23                                                                | 8 48.8                 | 2 49.0                                                                | 11 04.49         |             |  |
| Sun. 13                    | 23 09 39.9              | 9.87                   | 16 16.46               | 71                                                     | 5 47.11                                                                | 8 44.8                 | 2 45.1                                                                | 11 04.83         |             |  |
| Mon. 14                    | 23 13 23.0              | 8.72                   | 16 16.55               | 71                                                     | 5 18.66                                                                | 8 40.9                 | 2 41.1                                                                | 11 05.15         |             |  |
| Tues. 15                   | 23 16 38.4              | 7.56                   | 16 16.64               | 71                                                     | 4 49.92                                                                | 8 36.9                 | 2 37.2                                                                | 11 05.46         |             |  |
| Wed. 16                    | 23 19 25.9              | 6.40                   | 16 16.73               | 71                                                     | 4 20.90                                                                | 8 33.0                 | 2 33.2                                                                | 11 05.74         |             |  |
| Thur. 17                   | 23 21 45.4              | 5.23                   | 16 16.81               | 71                                                     | 3 51.64                                                                | 8 29.0                 | 2 29.3                                                                | 11 06.00         |             |  |
| Fri. 18                    | 23 23 36.9              | 4.06                   | 16 16.88               | 71                                                     | 3 22.18                                                                | 8 25.1                 | 2 25.3                                                                | 11 06.24         |             |  |
| Sat. 19                    | 23 25 00.3              | 2.89                   | 16 16.95               | 71                                                     | 2 52.55                                                                | 8 21.1                 | 2 21.4                                                                | 11 06.47         |             |  |
| Sun. 20                    | 23 25 55.5              | 1.71                   | 16 17.02               | 71                                                     | 2 22.78                                                                | 8 17.2                 | 2 17.4                                                                | 11 06.69         |             |  |
| Mon. 21                    | 23 26 22.4              | - 0.53                 | 16 17.08               | 71                                                     | 1 52.90                                                                | 8 13.2                 | 2 13.5                                                                | 11 06.91         |             |  |
| Tues. 22                   | 23 26 21.1              | + 0.64                 | 16 17.14               | 71                                                     | 1 22.96                                                                | 8 09.3                 | 2 09.5                                                                | 11 07.13         |             |  |
| Wed. 23                    | 23 25 51.5              | 1.82                   | 16 17.19               | 71                                                     | 0 53.00                                                                | 8 05.3                 | 2 05.6                                                                | 11 07.36         |             |  |
| Thur. 24                   | 23 24 53.7              | 3.00                   | 16 17.24               | 71                                                     | 0 23.04                                                                | 8 01.4                 | 2 01.6                                                                | 11 07.59         |             |  |
| Fri. 25                    | 23 23 27.6              | 4.18                   | 16 17.28               | 71                                                     | 0 06.87                                                                | 7 57.4                 | 1 57.7                                                                | 11 07.83         |             |  |
| Sat. 26                    | 23 21 33.2              | 5.35                   | 16 17.32               | 71                                                     | 0 36.70                                                                | 7 53.5                 | 1 53.7                                                                | 11 08.07         |             |  |
| Sun. 27                    | 23 19 10.8              | 6.52                   | 16 17.36               | 71                                                     | 1 06.40                                                                | 7 49.5                 | 1 49.8                                                                | 11 08.31         |             |  |
| Mon. 28                    | 23 16 20.2              | 7.69                   | 16 17.39               | 71                                                     | 1 35.94                                                                | 7 45.6                 | 1 45.8                                                                | 11 08.55         |             |  |
| Tues. 29                   | 23 13 01.5              | 8.86                   | 16 17.42               | 71                                                     | 2 05.29                                                                | 7 41.6                 | 1 41.9                                                                | 11 08.79         |             |  |
| Wed. 30                    | 23 09 15.0              | 10.02                  | 16 17.45               | 71                                                     | 2 34.40                                                                | 7 37.7                 | 1 37.9                                                                | 11 09.00         |             |  |
| Thur. 31                   | 23 05 00.6              | 11.18                  | 16 17.47               | 71                                                     | 3 03.24                                                                | 7 33.7                 | 1 34.0                                                                | 11 09.20         |             |  |
| Fri. 32                    | S23 00 18.5             | +12.33                 | 16 17.49               | 71                                                     | 3 31.78                                                                | 7 29.8 P.M.            | W.E. 1 30.0 A.M.                                                      | 11 09.38         |             |  |

The sign + prefixed to the hourly change of declination indicates that { north } declinations are { increasing. }  
south } decreasing.

The sign - prefixed to the hourly change of declination indicates that { south } declinations are { increasing. }  
north } decreasing.

| Serial<br>Number<br>this<br>list | No. from<br>Nautical<br>Almanac | Constellation<br>Name          | North Declination |       |       | South Declination |       |      |
|----------------------------------|---------------------------------|--------------------------------|-------------------|-------|-------|-------------------|-------|------|
|                                  |                                 |                                | R.A.              | Decl. | Mag.  | R.A.              | Decl. | Mag. |
|                                  |                                 |                                | h m               | °     |       | h m               | °     |      |
| 1                                | 1                               | α Andromedae (Alpheratz)       | 0 07              | +29   | 2.2   |                   |       |      |
| 2 x X                            |                                 | β Hydri                        |                   |       |       | 0 25              | -77   | 2.9  |
| 3                                | 4                               | β Ceti (Diphda)                |                   |       |       | 0 43              | -18   | 2.2  |
| 4 E                              |                                 | α Ursae Minoris (Polaris)      | 2 11              | +89   | 2.1   |                   |       |      |
| 5                                | 6                               | α Arietis (Hamal)              | 2 06              | +23   | 2.2   |                   |       |      |
| 6                                | 10                              | α Tauri (Aldebaran)            | 4 35              | +16   | 1.1   |                   |       |      |
| 7                                | 11                              | β Orionis (Rigel)              |                   |       |       | 5 14              | - 8   | 0.3  |
| 8                                | 12                              | α Aurigae (Capella)            | 5 15              | +46   | 0.2   |                   |       |      |
| 9                                | 16                              | α Orionis (Betelgeuse)         | 5 54              | + 7   | 0.5 v |                   |       |      |
| 10 x                             | 17                              | α Carinae (Canopus)            |                   |       |       | 6 24              | -53   | -0.9 |
| 11                               | 18                              | α Canis Majoris (Sirius)       |                   |       |       | 6 44              | -17   | -1.6 |
| 12                               | 20                              | α Canis Minoris (Procyon)      | 7 38              | + 5   | 0.5   |                   |       |      |
| 13                               | 21                              | β Geminorum (Pollux)           | 7 44              | +28   | 1.2   |                   |       |      |
| 14                               | 25                              | α Hydrae (Alphard)             |                   |       |       | 9 27              | - 9   | 2.2  |
| 15                               | 26                              | α Leonis (Regulus)             | 10 07             | +12   | 1.3   |                   |       |      |
| 16                               | 28                              | β Leonis (Denebola)            | 11 48             | +15   | 2.2   |                   |       |      |
| 17                               | 33                              | α Virginis (Spica)             |                   |       |       | 13 24             | -11   | 1.2  |
| 18 x                             | 36                              | θ Centauri (Menkent)           |                   |       |       | 14 06             | -36   | 2.3  |
| 19                               | 37                              | α Bootis (Arcturus)            | 14 15             | +19   | 0.2   |                   |       |      |
| 20                               | 41                              | α Coronae Borealis (Alphecca)  | 15 34             | +27   | 2.3   |                   |       |      |
| 21 x                             | 42                              | α Scorpii (Antares)            |                   |       |       | 16 28             | -26   | 1.2  |
| 22                               | 46                              | α Ophiuchi (Rasalhague)        | 17 34             | +13   | 2.1   |                   |       |      |
| 23                               | 49                              | α Lyrae (Vega)                 | 18 36             | +39   | 0.1   |                   |       |      |
| 24 x                             | 50                              | σ Sagittarii (Nunki)           |                   |       |       | 18 54             | -26   | 2.1  |
| 25                               | 51                              | α Aquilae (Altair)             | 19 50             | + 9   | 0.9   |                   |       |      |
| 26                               | 54                              | ε Pegasi (Enif)                | 21 43             | +10   | 2.5   |                   |       |      |
| 27 x                             | 56                              | α Piscis Australis (Fomalhaut) |                   |       |       | 22 57             | -30   | 1.3  |
| 28                               | 57                              | α Pegasi (Markab)              | 23 04             | +15   | 2.6   |                   |       |      |

x: Required for stations south of 30° north latitude.  
X: South circumpolar; not included in principal list of stars, Nautical Almanac.  
E: Tabulated in this Ephemeris for daily position, including elongation.  
v: Varies from 0.1 to 1.2 in magnitude or brilliancy.  
α: Alpha. β: Beta. ε: Epsilon. θ: Theta. σ: Sigma. These designations are in the order of brightness, each within its own constellation.

The planets and the bright stars Capella, Canopus, and Vega, are tabulated as an aid in finding stellar positions.

For the south circumpolar star, No. 2 β Hydri, the horizontal angles, and the hour angle at elongation, may be found by the following equations (the lat. and decl. being treated as positive):

At elongation:  $\cos t = \cot \delta \tan \phi$ ; and,  $\sin A = \frac{\cos \delta}{\cos \phi}$

At any hour angle:  $\tan A = \frac{\sin t}{\cos \phi \tan \delta - \sin \phi \cos t}$

The product,  $\sin \phi \cos t$ , is subtracted for hour angles 0° to 90°; added for hour angles 90° to 180°. The hour angle,  $t$ , in these equations is in sidereal rate; conversions page 27.

## STAR TABLES, MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME

| No.                  | Mag.             |                                    |                           |                                    |                           |                                          |                           |                                          |                           | Transit                         |              |
|----------------------|------------------|------------------------------------|---------------------------|------------------------------------|---------------------------|------------------------------------------|---------------------------|------------------------------------------|---------------------------|---------------------------------|--------------|
|                      |                  | Transit                            | Decl.                     | Transit                            | Decl.                     | Transit                                  | Decl.                     | Transit                                  | Decl.                     | Subtract<br>for day<br>of month |              |
|                      |                  | Jan. 1                             |                           | Jan. 16                            |                           | Feb. 1                                   |                           | Feb. 16                                  |                           |                                 |              |
|                      |                  | <sup>h</sup> <sup>m</sup>          | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>          | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>                | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>                | <sup>°</sup> <sup>'</sup> |                                 | <sup>m</sup> |
| 1- 1                 | 2.2              | 5 22.3 PM                          | +28 59.2                  | 4 23.3 PM                          | 59.2                      | 3 20.4 PM                                | 59.1                      | 2 21.4 PM                                | 59.1                      | 1                               | 0.0          |
| 2                    | 2.9              | 5 39.6                             | -77 22.1                  | 4 40.6                             | 22.1                      | 3 37.7                                   | 22.0                      | 2 38.7                                   | 22.0                      | 2                               | 3.9          |
| 3- 4                 | 2.2              | 5 57.4                             | -18 05.7                  | 4 58.5                             | 05.7                      | 3 55.5                                   | 05.7                      | 2 56.6                                   | 05.7                      | 3                               | 7.9          |
| 4                    | 2.1              | 7 28.1                             | +89 10.9                  | 6 28.8                             | 10.9                      | 5 25.5                                   | 10.9                      | 4 26.1                                   | 10.9                      | 4                               | 11.8         |
| 5- 6                 | 2.2              | 7 20.7                             | +23 22.4                  | 6 21.7                             | 22.4                      | 5 18.8                                   | 22.3                      | 4 19.8                                   | 22.3                      | 5                               | 15.7         |
| 6-10                 | 1.1              | 9 49.0                             | +16 28.2                  | 8 50.0                             | 28.2                      | 7 47.1                                   | 28.2                      | 6 48.1                                   | 28.2                      | 6                               | 19.7         |
| 7-11                 | 0.3              | 10 27.7                            | - 8 13.5                  | 9 28.7                             | 13.6                      | 8 25.8                                   | 13.6                      | 7 26.8                                   | 13.6                      | 7                               | 23.6         |
| 8-12                 | 0.2              | 10 29.4                            | +45 58.8                  | 9 30.4                             | 58.8                      | 8 27.5                                   | 58.8                      | 7 28.5                                   | 58.8                      | 8                               | 27.5         |
| 9-16                 | 0.5 <sub>v</sub> | 11 08.1                            | + 7 24.1                  | 10 09.1                            | 24.1                      | 9 06.2                                   | 24.1                      | 8 07.2                                   | 24.1                      | 9                               | 31.5         |
| 10-17                | -0.9             | 11 37.4 PM                         | -52 41.2                  | 10 38.5                            | 41.3                      | 9 35.6                                   | 41.4                      | 8 36.6                                   | 41.4                      | 10                              | 35.4         |
| 11-18                | -1.6             | { 0 02.1 AM<br>11 58.1 PM }        | -16 41.5                  | 10 59.2                            | 41.5                      | 9 56.3                                   | 41.6                      | 8 57.3                                   | 41.6                      | 11                              | 39.3         |
| 12-20                | 0.5              | { 0 55.9 AM<br>0 00.9 AM }         | + 5 16.4                  | 11 53.0 PM                         | 16.3                      | 10 50.1                                  | 16.3                      | 9 51.1                                   | 16.3                      | 12                              | 43.2         |
| Jan. 15              |                  | { 11 56.9 PM }                     |                           |                                    |                           |                                          |                           |                                          |                           | 13                              | 47.2         |
| 13-21                | 1.2              | 1 01.8 AM                          | +28 04.3                  | { 0 02.8 AM<br>11 58.8 PM }        | 04.3                      | 10 55.9 PM                               | 04.3                      | 9 57.0                                   | 04.3                      | 14                              | 51.1         |
| 14-25                | 2.2              | 2 44.0                             | - 8 34.5                  | 1 45.0 AM                          | 34.6                      | { 0 42.1 AM<br>0 02.8 AM<br>11 58.8 PM } | 34.6                      | 11 39.2 PM                               | 34.7                      | 15                              | 55.0         |
| Feb. 11              |                  |                                    |                           |                                    |                           |                                          |                           |                                          |                           | 16                              | 0.0          |
| 15-26                | 1.3              | 3 24.6                             | +12 03.6                  | 2 25.6                             | 03.5                      | 1 22.7 AM                                | 03.5                      | { 0 23.7 AM<br>0 00.1 AM<br>11 56.2 PM } | 03.5                      | 17                              | 3.9          |
| Feb. 22              |                  |                                    |                           |                                    |                           |                                          |                           |                                          |                           | 18                              | 7.9          |
| 16-28                | 2.2              | 5 05.0                             | +14 40.7                  | 4 06.0                             | 40.6                      | 3 03.1                                   | 40.6                      | 2 04.2 AM                                | 40.6                      | 19                              | 11.8         |
| 17-33                | 1.2              | 6 40.8 <sup>3</sup> / <sub>4</sub> | -11 03.6                  | 5 41.9 <sup>3</sup> / <sub>4</sub> | 03.6                      | 4 39.0 <sup>3</sup> / <sub>4</sub>       | 03.7                      | 3 40.0 <sup>3</sup> / <sub>4</sub>       | 03.7                      | 20                              | 15.7         |
| 18-36                | 2.3              | 7 22.1                             | -36 16.3                  | 6 23.1                             | 16.4                      | 5 20.2                                   | 16.4                      | 4 21.3                                   | 16.5                      | 21                              | 19.7         |
| 19-37                | 0.2              | 7 31.3                             | +19 16.9                  | 6 32.3                             | 16.8                      | 5 29.4                                   | 16.8                      | 4 30.5                                   | 16.7                      | 22                              | 23.6         |
| 20-41                | 2.3              | 8 50.2                             | +26 46.7                  | 7 51.2                             | 46.6                      | 6 48.3                                   | 46.6                      | 5 49.3                                   | 46.5                      | 23                              | 27.5         |
| 21-42                | 1.2              | 9 44.4 <sup>1</sup>                | -26 23.3                  | 8 45.4                             | 23.3                      | 7 42.5                                   | 23.3                      | 6 43.5                                   | 23.3                      | 24                              | 31.5         |
| 22-46                | 2.1              | 10 50.0                            | +12 34.5                  | 9 51.0                             | 34.4                      | 8 48.1                                   | 34.3                      | 7 49.2                                   | 34.3                      | 25                              | 35.4         |
| 23-49                | 0.1              | 11 52.1 AM                         | +38 46.0                  | 10 53.1                            | 45.9                      | 9 50.2                                   | 45.8                      | 8 51.2                                   | 45.8                      | 26                              | 39.3         |
| 24-50                | 2.1              | 12 09.8 PM                         | -26 19.2                  | 11 10.8 AM <sup>1</sup>            | 19.2                      | 10 07.9 <sup>1</sup>                     | 19.2                      | 9 09.0                                   | 19.2                      | 27                              | 43.2         |
| 25-51                | 0.9              | 1 05.4                             | + 8 49.1                  | 12 06.5 PM                         | 49.1                      | 11 03.6 AM                               | 49.0                      | 10 04.6                                  | 49.0                      | 28                              | 47.2         |
| 26-54                | 2.5              | 2 58.5                             | + 9 47.3                  | 1 59.6                             | 47.2                      | 12 56.6 PM                               | 47.2                      | 11 57.7 AM                               | 47.2                      | 29                              | 51.1         |
| 27-56                | 1.3              | 4 11.7                             | -29 43.6                  | 3 12.7                             | 43.6                      | 2 09.8                                   | 43.6                      | 1 10.8 PM                                | 43.6                      | 30                              | 55.0         |
| 28-57                | 2.6              | 4 18.9 PM                          | +15 06.2                  | 3 19.9 PM                          | 06.1                      | 2 17.0 PM                                | 06.1                      | 1 18.0 PM                                | 06.1                      | 31                              | 59.0         |
|                      |                  |                                    |                           |                                    |                           |                                          |                           |                                          |                           |                                 |              |
| <sup>1</sup> Venus   | -3.4             | 10 23 AM                           | -22                       | 10 45 AM                           | -23                       | 11 08 AM                                 | -21                       | 11 27 AM                                 | -17                       |                                 |              |
| <sup>2</sup> Mars    | 1.4              | 1 31 PM                            | -21                       | 1 20 PM                            | -18                       | 1 07 PM                                  | -14                       | 12 53 PM                                 | -10                       |                                 |              |
| <sup>3</sup> Jupiter | -1.8             | 5 54 AM                            | - 3                       | 4 58 AM                            | - 3                       | 3 55 AM                                  | - 3                       | 2 54 AM                                  | - 2                       |                                 |              |
| <sup>4</sup> Saturn  | 0.9              | 5 55 AM                            | - 2                       | 4 58 AM                            | - 2                       | 3 54 AM                                  | - 2                       | 2 53 AM                                  | - 1                       |                                 |              |

Footnotes indicate near proximity of a planet to a star in time of transit and declination.

For time of transit subsequent to a star's double transit and until the next tabulated date, subtract for the number of days counting from the second transit of that date. All other interpolations may be taken directly by reference to the day of the month.

STAR TABLES, MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME

| No.                  | Mag.             |                                    |                           |                                            |              |                                                                        |              |                                            |              | Transit                         |              |
|----------------------|------------------|------------------------------------|---------------------------|--------------------------------------------|--------------|------------------------------------------------------------------------|--------------|--------------------------------------------|--------------|---------------------------------|--------------|
|                      |                  | Transit                            | Decl.                     | Transit                                    | Decl.        | Transit                                                                | Decl.        | Transit                                    | Decl.        | Subtract<br>for day<br>of month |              |
|                      |                  | Mar. 1                             |                           | Mar. 16                                    |              | Apr. 1                                                                 |              | Apr. 16                                    |              |                                 |              |
|                      |                  | <sup>h</sup> <sup>m</sup>          | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>                  | <sup>'</sup> | <sup>h</sup> <sup>m</sup>                                              | <sup>'</sup> | <sup>h</sup> <sup>m</sup>                  | <sup>'</sup> |                                 | <sup>m</sup> |
| 1- 1                 | 2.2              | 1 30.3 PM                          | +28 59.1                  | 12 31.3 PM                                 | 59.0         | 11 28.4 AM                                                             | 59.0         | 10 29.5 AM                                 | 59.0         | 1                               | 0.0          |
| 2                    | 2.9              | 1 47.5                             | -77 21.9                  | 12 48.6                                    | 21.8         | 11 45.7 AM                                                             | 21.7         | 10 46.7                                    | 21.6         | 2                               | 3.9          |
| 3- 4                 | 2.2              | 2 05.4                             | -18 05.7                  | 1 06.5                                     | 05.6         | 12 03.6 PM                                                             | 05.6         | 11 04.6 AM                                 | 05.5         | 3                               | 7.9          |
| 4                    | 2.1              | 3 34.7                             | +89 10.9                  | 2 35.5                                     | 10.8         | 1 32.4                                                                 | 10.7         | 12 33.3 PM                                 | 10.7         | 4                               | 11.8         |
| 5- 6                 | 2.2              | 3 28.7                             | +23 22.3                  | 2 29.7                                     | 22.3         | 1 26.8                                                                 | 22.3         | 12 27.8                                    | 22.2         | 5                               | 15.7         |
| 6-10                 | 1.1              | 5 57.0                             | +16 28.2                  | 4 58.0                                     | 28.2         | 3 55.1                                                                 | 28.2         | 2 56.2                                     | 28.2         | 6                               | 19.7         |
| 7-11                 | 0.3              | 6 35.7                             | - 8 13.6                  | 5 36.7                                     | 13.6         | 4 33.8                                                                 | 13.6         | 3 34.8                                     | 13.6         | 7                               | 23.6         |
| 8-12                 | 0.2              | 6 37.4                             | +45 58.8                  | 5 38.4                                     | 58.8         | 4 35.5                                                                 | 58.8         | 3 36.5                                     | 58.8         | 8                               | 27.5         |
| 9-16                 | 0.5 <sub>v</sub> | 7 16.1                             | + 7 24.1                  | 6 17.1                                     | 24.1         | 5 14.2                                                                 | 24.1         | 4 15.3                                     | 24.1         | 9                               | 31.5         |
| 10-17                | -0.9             | 7 45.4                             | -52 41.5                  | 6 46.5                                     | 41.5         | 5 43.5                                                                 | 41.5         | 4 44.6                                     | 41.5         | 10                              | 35.4         |
| 11-18                | -1.6             | 8 06.2                             | -16 41.6                  | 7 07.2                                     | 41.7         | 6 04.3                                                                 | 41.7         | 5 05.3                                     | 41.7         | 11                              | 39.3         |
| 12-20                | 0.5              | 9 00.0                             | + 5 16.3                  | 8 01.0                                     | 16.3         | 6 58.1                                                                 | 16.3         | 5 59.1                                     | 16.3         | 12                              | 43.2         |
| 13-21                | 1.2              | 9 05.8                             | +28 04.3                  | 8 06.9                                     | 04.3         | 7 04.0                                                                 | 04.3         | 6 05.0                                     | 04.4         | 13                              | 47.2         |
| 14-25                | 2.2              | 10 48.1                            | - 8 34.7                  | 9 49.1                                     | 34.7         | 8 46.2                                                                 | 34.8         | 7 47.2                                     | 34.8         | 14                              | 51.1         |
| 15-26                | 1.3              | 11 28.7 PM                         | +12 03.5                  | 10 29.7 PM                                 | 03.5         | 9 26.8                                                                 | 03.5         | 8 27.8                                     | 03.5         | 15                              | 55.0         |
| 16-28                | 2.2              | 1 13.1 AM                          | +14 40.6                  | 0 14.1 AM<br>{ 0 02.3 AM }<br>[11 58.3 PM] | 40.6         | 11 07.2 PM                                                             | 40.6         | 10 08.3                                    | 40.6         | 16                              | 0.0          |
| Mar. 19              |                  |                                    |                           |                                            |              |                                                                        |              |                                            |              | 17                              | 3.9          |
| 17-33                | 1.2              | 2 48.9 <sup>3</sup> / <sub>4</sub> | -11 03.8                  | 1 49.9 AM <sup>3</sup> / <sub>4</sub>      | 03.8         | 0 47.0 AM <sup>3</sup> / <sub>4</sub><br>{ 0 03.8 AM }<br>[11 59.8 PM] | 03.8         | 11 44.1 PM <sup>3</sup> / <sub>4</sub>     | 03.8         | 18                              | 7.9          |
| Apr. 12              |                  |                                    |                           |                                            |              |                                                                        |              |                                            |              | 19                              | 11.8         |
| 18-36                | 2.3              | 3 30.2                             | -36 16.5                  | 2 31.2                                     | 16.6         | 1 28.3 AM                                                              | 16.6         | 0 29.3 AM<br>{ 0 01.8 AM }<br>[11 57.8 PM] | 16.7         | 20                              | 15.7         |
| Apr. 23              |                  |                                    |                           |                                            |              |                                                                        |              |                                            |              | 21                              | 19.7         |
| 19-37                | 0.2              | 3 39.4                             | +19 16.7                  | 2 40.4                                     | 16.7         | 1 37.5                                                                 | 16.7         | 0 38.5 AM<br>{ 0 03.1 AM }<br>[11 59.2 PM] | 16.8         | 22                              | 23.6         |
| Apr. 25              |                  |                                    |                           |                                            |              |                                                                        |              |                                            |              | 23                              | 27.5         |
| 20-41                | 2.3              | 4 58.2                             | +26 46.5                  | 3 59.3                                     | 46.5         | 2 56.4                                                                 | 46.5         | 1 57.4 AM                                  | 46.6         | 24                              | 31.5         |
| 21-42                | 1.2              | 5 52.4                             | -26 23.3                  | 4 53.5                                     | 23.4         | 3 50.6                                                                 | 23.4         | 2 51.6                                     | 23.4         | 25                              | 35.4         |
| 22-46                | 2.1              | 6 58.1                             | +12 34.3                  | 5 59.1                                     | 34.3         | 4 56.2                                                                 | 34.3         | 3 57.2                                     | 34.3         | 26                              | 39.3         |
| 23-49                | 0.1              | 8 00.1                             | +38 45.7                  | 7 01.1                                     | 45.7         | 5 58.3                                                                 | 45.7         | 4 59.3                                     | 45.7         | 27                              | 43.2         |
| 24-50                | 2.1              | 8 17.9                             | -26 19.2                  | 7 18.9                                     | 19.2         | 6 16.0                                                                 | 19.2         | 5 17.0                                     | 19.2         | 28                              | 47.2         |
| 25-51                | 0.9              | 9 13.5                             | + 8 49.0                  | 8 14.5                                     | 48.9         | 7 11.6                                                                 | 48.9         | 6 12.6                                     | 48.9         | 29                              | 51.1         |
| 26-54                | 2.5              | 11 06.6 AM                         | + 9 47.1                  | 10 07.6                                    | 47.1         | 9 04.7                                                                 | 47.1         | 8 05.7                                     | 47.1         | 30                              | 55.0         |
| 27-56                | 1.3              | 12 19.7 PM                         | -29 43.5                  | 11 20.7                                    | 43.5         | 10 17.8                                                                | 43.4         | 9 18.8                                     | 43.4         | 31                              | 59.0         |
| 28-57                | 2.6              | 12 26.9 PM                         | +15 06.0                  | 11 27.9 AM                                 | 06.0         | 10 25.0 AM                                                             | 06.0         | 9 26.0 AM                                  | 06.0         |                                 |              |
| <sup>1</sup> Venus   | -3.4             | 11 39 AM                           | -12                       | 11 51 AM                                   | - 5          | 12 00 PM                                                               | + 3          | 12 10 PM                                   | +10          |                                 |              |
| <sup>2</sup> Mars    | 1.4              | 12 40 PM                           | - 6                       | 12 24 PM                                   | - 1          | 12 06 PM                                                               | + 4          | 11 49 AM                                   | + 9          |                                 |              |
| <sup>3</sup> Jupiter | -2.0             | 1 58 AM                            | - 2                       | 0 53 AM                                    | - 1          | 11 39 PM                                                               | + 0          | 10 33 PM                                   | + 0          |                                 |              |
| <sup>4</sup> Saturn  | 0.7              | 2 00 AM                            | - 1                       | 0 57 AM                                    | + 0          | 11 45 PM                                                               | + 0          | 10 42 PM                                   | + 0          |                                 |              |

Footnotes indicate near proximity of a planet to a star in time of transit and declination.

For reduction of time of transit from the Greenwich mean time to the local mean time at the longitude of the station, see table of Sidereal Conversions, page 27.

STAR TABLES, MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME

| No.                  | Mag.             |                                            |                                       |                                            |                      |                                            |                      |                                        |                      | Transit                         |                     |
|----------------------|------------------|--------------------------------------------|---------------------------------------|--------------------------------------------|----------------------|--------------------------------------------|----------------------|----------------------------------------|----------------------|---------------------------------|---------------------|
|                      |                  | Transit                                    | Decl.                                 | Transit                                    | Decl.                | Transit                                    | Decl.                | Transit                                | Decl.                | Subtract<br>for day<br>of month |                     |
|                      |                  | May 1                                      |                                       | May 16                                     |                      | June 1                                     |                      | June 16                                |                      |                                 |                     |
| 1- 1                 | 2.2              | <sup>h</sup> <sup>m</sup><br>9 30.5 AM     | <sup>°</sup> <sup>'</sup><br>+28 58.9 | <sup>h</sup> <sup>m</sup><br>8 31.5 AM     | <sup>'</sup><br>59.0 | <sup>h</sup> <sup>m</sup><br>7 28.6 AM     | <sup>'</sup><br>59.0 | <sup>h</sup> <sup>m</sup><br>6 29.6 AM | <sup>'</sup><br>59.0 | 1                               | <sup>m</sup><br>0.0 |
| 2                    | 2.9              | 9 47.7                                     | -77 21.5                              | 8 48.8                                     | 21.4                 | 7 45.9                                     | 21.4                 | 6 46.9                                 | 21.3                 | 2                               | 3.9                 |
| 3- 4                 | 2.2              | 10 05.6                                    | -18 05.5                              | 9 06.6                                     | 05.4                 | 8 03.7                                     | 05.4                 | 7 04.8                                 | 05.3                 | 3                               | 7.9                 |
| 4                    | 2.1              | 11 34.3                                    | +89 10.6                              | 10 35.5                                    | 10.5                 | 9 32.8                                     | 10.4                 | 8 34.1                                 | 10.4                 | 4                               | 11.8                |
| 5- 6                 | 2.2              | 11 28.9 AM <sup>1</sup> <sub>2</sub>       | +23 22.2                              | 10 29.9 AM <sup>2</sup>                    | 22.2                 | 9 27.0                                     | 22.2                 | 8 28.0                                 | 22.3                 | 5                               | 15.7                |
| 6-10                 | 1.1              | 1 57.2 PM                                  | +16 28.2                              | 12 58.2 PM <sup>1</sup>                    | 28.2                 | 11 55.3 AM <sup>1</sup> <sub>2</sub>       | 28.2                 | 10 56.3 <sup>2</sup>                   | 28.2                 | 6                               | 19.7                |
| 7-11                 | 0.3              | 2 35.9                                     | - 8 13.6                              | 1 36.9                                     | 13.5                 | 12 34.0 PM                                 | 13.5                 | 11 35.0                                | 13.5                 | 7                               | 23.6                |
| 8-12                 | 0.2              | 2 37.5                                     | +45 58.8                              | 1 38.5                                     | 58.8                 | 12 35.6                                    | 58.7                 | 11 36.7 AM                             | 58.7                 | 8                               | 27.5                |
| 9-16                 | 0.5 <sub>v</sub> | 3 16.3                                     | + 7 24.1                              | 2 17.3                                     | 24.1                 | 1 14.4                                     | 24.1                 | 12 15.4 PM                             | 24.2                 | 9                               | 31.5                |
| 10-17                | -0.9             | 3 45.6                                     | -52 41.4                              | 2 46.6                                     | 41.4                 | 1 43.7                                     | 41.3                 | 12 44.7                                | 41.2                 | 10                              | 35.4                |
| 11-18                | -1.6             | 4 06.3                                     | -16 41.6                              | 3 07.3                                     | 41.6                 | 2 04.4                                     | 41.6                 | 1 05.4                                 | 41.5                 | 11                              | 39.3                |
| 12-20                | 0.5              | 5 00.2                                     | + 5 16.3                              | 4 01.2                                     | 16.3                 | 2 58.3                                     | 16.3                 | 1 59.3                                 | 16.4                 | 12                              | 43.2                |
| 13-21                | 1.2              | 5 06.0                                     | +28 04.4                              | 4 07.0                                     | 04.4                 | 3 04.1                                     | 04.4                 | 2 05.1 <sup>1</sup>                    | 04.3                 | 13                              | 47.2                |
| 14-25                | 2.2              | 6 48.2                                     | - 8 34.8                              | 5 49.2                                     | 34.7                 | 4 46.3                                     | 34.7                 | 3 47.4                                 | 34.7                 | 14                              | 51.1                |
| 15-26                | 1.3              | 7 28.8                                     | +12 03.5                              | 6 29.8                                     | 03.6                 | 5 26.9                                     | 03.6                 | 4 27.9                                 | 03.6                 | 15                              | 55.0                |
| 16-28                | 2.2              | 9 09.3                                     | +14 40.6                              | 8 10.3                                     | 40.7                 | 7 07.4                                     | 40.7                 | 6 08.4                                 | 40.7                 | 16                              | 0.0                 |
| 17-33                | 1.2              | 10 45.1 <sup>4</sup>                       | -11 03.9                              | 9 46.1                                     | 03.9                 | 8 43.2                                     | 03.8                 | 7 44.3                                 | 03.8                 | 17                              | 3.9                 |
| 18-36                | 2.3              | 11 26.4                                    | -36 16.7                              | 10 27.4                                    | 16.7                 | 9 24.5                                     | 16.8                 | 8 25.5                                 | 16.8                 | 18                              | 7.9                 |
| 19-37                | 0.2              | 11 35.6 PM                                 | +19 16.8                              | 10 36.6                                    | 16.8                 | 9 33.7                                     | 16.9                 | 8 34.7                                 | 16.9                 | 19                              | 11.8                |
| 20-41                | 2.3              | 0 58.4 AM<br>{ 0 03.3 AM }<br>11 59.4 PM } | +26 46.6                              | 11 55.5 PM                                 | 46.7                 | 10 52.6                                    | 46.7                 | 9 53.6                                 | 46.8                 | 20                              | 15.7                |
| May 15               |                  |                                            |                                       |                                            |                      |                                            |                      |                                        |                      | 21                              | 19.7                |
| 21-42                | 1.2              | 1 52.6 AM                                  | -26 23.4                              | 0 53.6 AM<br>{ 0 02.5 AM }<br>11 58.6 PM } | 23.4                 | 11 46.8 PM                                 | 23.4                 | 10 47.8                                | 23.4                 | 22                              | 23.6                |
| May 29               |                  |                                            |                                       |                                            |                      |                                            |                      |                                        |                      | 23                              | 27.5                |
| 22-46                | 2.1              | 2 58.2                                     | +12 34.3                              | 1 59.3 AM                                  | 34.4                 | 0 56.4 AM<br>{ 0 01.3 AM }<br>11 57.4 PM } | 34.4                 | 11 53.4 PM                             | 34.5                 | 24                              | 31.5                |
| June 15              |                  |                                            |                                       |                                            |                      |                                            |                      |                                        |                      | 25                              | 35.4                |
| 23-49                | 0.1              | 4 00.3                                     | +38 45.8                              | 3 01.3                                     | 45.8                 | 1 58.4 AM                                  | 45.9                 | 0 59.5 AM                              | 46.0                 | 26                              | 39.3                |
| 24-50                | 2.1              | 4 18.1                                     | -26 19.2                              | 3 19.1                                     | 19.2                 | 2 16.2                                     | 19.2                 | 1 17.2                                 | 19.1                 | 27                              | 43.2                |
| 25-51                | 0.9              | 5 13.7                                     | + 8 49.0                              | 4 14.7                                     | 49.0                 | 3 11.8                                     | 49.1                 | 2 12.8                                 | 49.1                 | 28                              | 47.2                |
| 26-54                | 2.5              | 7 06.7                                     | + 9 47.1                              | 6 07.8                                     | 47.2                 | 5 04.9                                     | 47.2                 | 4 05.9                                 | 47.3                 | 29                              | 51.1                |
| 27-56                | 1.3              | 8 19.9                                     | -29 43.3                              | 7 20.9                                     | 43.3                 | 6 18.0                                     | 43.2                 | 5 19.0                                 | 43.2                 | 30                              | 55.0                |
| 28-57                | 2.6              | 8 27.1 AM                                  | +15 06.0                              | 7 28.1 AM                                  | 06.1                 | 6 25.2 AM                                  | 06.1                 | 5 26.2 AM                              | 06.1                 | 31                              | 59.0                |
|                      |                  |                                            |                                       |                                            |                      |                                            |                      |                                        |                      |                                 |                     |
|                      |                  |                                            |                                       |                                            |                      |                                            |                      |                                        |                      |                                 |                     |
| <sup>1</sup> Venus   | -3.4             | 12 23 PM                                   | +17                                   | 12 39 PM                                   | +21                  | 1 00 PM                                    | +24                  | 1 22 PM                                | +24                  |                                 |                     |
| <sup>2</sup> Mars    | 1.6              | 11 33 AM                                   | +13                                   | 11 17 AM                                   | +16                  | 11 01 AM                                   | +20                  | 10 46 AM                               | +22                  |                                 |                     |
| <sup>3</sup> Jupiter | -1.7             | 9 29 PM                                    | + 1                                   | 8 27 PM                                    | + 1                  | 7 23 PM                                    | + 1                  | 6 26 PM                                | + 1                  |                                 |                     |
| <sup>4</sup> Saturn  | 1.1              | 9 40 PM                                    | + 1                                   | 8 38 PM                                    | + 1                  | 7 34 PM                                    | + 1                  | 6 36 PM                                | + 1                  |                                 |                     |

Footnotes indicate near proximity of a planet to a star in time of transit and declination.

For time of transit subsequent to a star's double transit and until the next tabulated date, subtract for the number of days counting from the second transit of that date. All other interpolations may be taken directly by reference to the day of the month.

STAR TABLES, MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME

| No.                  | Mag.             |                                  |                           |                                          |                           |                                  |                           |                                          |                           | Transit                   |                           |
|----------------------|------------------|----------------------------------|---------------------------|------------------------------------------|---------------------------|----------------------------------|---------------------------|------------------------------------------|---------------------------|---------------------------|---------------------------|
|                      |                  | Transit                          | Decl.                     | Transit                                  | Decl.                     | Transit                          | Decl.                     | Transit                                  | Decl.                     | Subtract                  |                           |
|                      |                  | July 1                           |                           | July 16                                  |                           | Aug. 1                           |                           | Aug. 16                                  |                           | for day of month          |                           |
|                      |                  | <sup>h</sup> <sup>m</sup>        | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>                | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>        | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>                | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup> | <sup>°</sup> <sup>'</sup> |
| 1- 1                 | 2.2              | 5 30.7 AM                        | +28 59.1                  | 4 31.7 AM                                | 59.1                      | 3 28.8 AM                        | 59.2                      | 2 29.8 AM                                | 59.2                      | 1                         | 0.0                       |
| 2                    | 2.9              | 5 48.0                           | -77 21.3                  | 4 49.0                                   | 21.3                      | 3 46.1                           | 21.3                      | 2 47.2                                   | 21.3                      | 2                         | 3.9                       |
| 3- 4                 | 2.2              | 6 05.8                           | -18 05.3                  | 5 06.8                                   | 05.2                      | 4 03.9                           | 05.2                      | 3 05.0                                   | 05.2                      | 3                         | 7.9                       |
| 4                    | 2.1              | 7 35.5                           | +89 10.4                  | 6 36.9                                   | 10.4                      | 5 34.4                           | 10.4                      | 4 35.8                                   | 10.4                      | 4                         | 11.8                      |
| 5- 6                 | 2.2              | 7 29.0                           | +23 22.3                  | 6 30.1                                   | 22.3                      | 5 27.2                           | 22.4                      | 4 28.2                                   | 22.4                      | 5                         | 15.7                      |
| 6-10                 | 1.1              | 9 57.3 <sup>2</sup>              | +16 28.2                  | 8 58.4                                   | 28.3                      | 7 55.5                           | 28.3                      | 6 56.5                                   | 28.3                      | 6                         | 19.7                      |
| 7-11                 | 0.3              | 10 36.0                          | - 8 13.4                  | 9 37.1                                   | 13.4                      | 8 34.2                           | 13.3                      | 7 35.2                                   | 13.3                      | 7                         | 23.6                      |
| 8-12                 | 0.2              | 10 37.7                          | +45 58.7                  | 9 38.7                                   | 58.6                      | 8 35.8                           | 58.6                      | 7 36.8                                   | 58.6                      | 8                         | 27.5                      |
| 9-16                 | 0.5 <sub>v</sub> | 11 16.4                          | + 7 24.2                  | 10 17.5                                  | 24.2                      | 9 14.6                           | 24.3                      | 8 15.6                                   | 24.3                      | 9                         | 31.5                      |
| 10-17                | -0.9             | 11 45.7 AM                       | -52 41.2                  | 10 46.8                                  | 41.1                      | 9 43.8                           | 41.0                      | 8 44.9                                   | 40.9                      | 10                        | 35.4                      |
| 11-18                | -1.6             | 12 06.5 PM                       | -16 41.5                  | 11 07.5 AM                               | 41.4                      | 10 04.6                          | 41.3                      | 9 05.6                                   | 41.3                      | 11                        | 39.3                      |
| 12-20                | 0.5              | 1 00.3                           | + 5 16.4                  | 12 01.3 PM                               | 16.4                      | 10 58.4                          | 16.4                      | 9 59.5                                   | 16.4                      | 12                        | 43.2                      |
| 13-21                | 1.2              | 1 06.1 <sup>1</sup>              | +28 04.3                  | 12 07.2                                  | 04.3                      | 11 04.3 AM <sup>2</sup>          | 04.3                      | 10 05.3 <sup>2</sup>                     | 04.3                      | 13                        | 47.2                      |
| 14-25                | 2.2              | 2 48.4                           | - 8 34.7                  | 1 49.4                                   | 34.6                      | 12 46.5 PM                       | 34.6                      | 11 47.5 AM                               | 34.6                      | 14                        | 51.1                      |
| 15-26                | 1.3              | 3 29.0                           | +12 03.6                  | 2 30.0 <sup>1</sup>                      | 03.6                      | 1 27.1 <sup>1</sup>              | 03.6                      | 12 28.1 PM                               | 03.6                      | 15                        | 55.0                      |
| 16-28                | 2.2              | 5 09.4                           | +14 40.7                  | 4 10.5                                   | 40.7                      | 3 07.5 <sup>1</sup>              | 40.7                      | 2 08.6                                   | 40.7                      | 16                        | 0.0                       |
| 17-33                | 1.2              | 6 45.3 <sup>3</sup> <sup>4</sup> | -11 03.8                  | 5 46.3 <sup>3</sup> <sup>4</sup>         | 03.8                      | 4 43.4 <sup>3</sup> <sup>4</sup> | 03.8                      | 3 44.4 <sup>3</sup> <sup>4</sup>         | 03.8                      | 17                        | 3.9                       |
| 18-36                | 2.3              | 7 26.5                           | -36 16.8                  | 6 27.6                                   | 16.8                      | 5 24.7                           | 16.8                      | 4 25.7                                   | 16.8                      | 18                        | 7.9                       |
| 19-37                | 0.2              | 7 35.7                           | +19 16.9                  | 6 36.8                                   | 17.0                      | 5 33.9                           | 17.0                      | 4 34.9                                   | 17.0                      | 19                        | 11.8                      |
| 20-41                | 2.3              | 8 54.6                           | +26 46.8                  | 7 55.6                                   | 46.9                      | 6 52.7                           | 46.9                      | 5 53.8                                   | 46.9                      | 20                        | 15.7                      |
| 21-42                | 1.2              | 9 48.8                           | -26 23.5                  | 8 49.9                                   | 23.5                      | 7 47.0                           | 23.5                      | 6 48.0                                   | 23.5                      | 21                        | 19.7                      |
| 22-46                | 2.1              | 10 54.5 PM                       | +12 34.5                  | 9 55.5                                   | 34.5                      | 8 52.6                           | 34.6                      | 7 53.6                                   | 34.6                      | 22                        | 23.6                      |
| 23-49                | 0.1              | { 0 00.5 AM<br>11 56.5 PM }      | +38 46.0                  | 10 57.6                                  | 46.1                      | 9 54.7                           | 46.2                      | 8 55.7                                   | 46.2                      | 23                        | 27.5                      |
| 24-50                | 2.1              | { 0 18.2 AM<br>0 02.5 AM }       | -26 19.1                  | 11 15.3 PM                               | 19.2                      | 10 12.4                          | 19.2                      | 9 13.4                                   | 19.2                      | 24                        | 31.5                      |
| July 5               |                  | { 11 58.6 PM }                   |                           |                                          |                           |                                  |                           |                                          |                           | 25                        | 35.4                      |
| 25-51                | 0.9              | 1 13.8 AM                        | + 8 49.2                  | 0 14.9 AM<br>{ 0 03.1 AM<br>11 59.1 PM } | 49.2                      | 11 08.0 PM                       | 49.3                      | 10 09.0 PM                               | 49.3                      | 26                        | 39.3                      |
| July 19              |                  |                                  |                           |                                          |                           |                                  |                           |                                          |                           | 27                        | 43.2                      |
| 26-54                | 2.5              | 3 06.9                           | + 9 47.3                  | 2 08.0 AM                                | 47.4                      | 1 05.1 AM                        | 47.4                      | 0 06.1 AM<br>{ 0 02.1 AM<br>11 58.2 PM } | 47.5                      | 28                        | 47.2                      |
| Aug. 17              |                  |                                  |                           |                                          |                           |                                  |                           |                                          |                           | 29                        | 51.1                      |
| 27-56                | 1.3              | 4 20.1                           | -29 43.1                  | 3 21.1                                   | 43.1                      | 2 18.2                           | 43.1                      | 1 19.2 AM                                | 43.1                      | 30                        | 55.0                      |
| 28-57                | 2.6              | 4 27.3 AM                        | +15 06.2                  | 3 28.3 AM                                | 06.3                      | 2 25.4 AM                        | 06.3                      | 1 26.4 AM                                | 06.4                      | 31                        | 59.0                      |
| <sup>1</sup> Venus   | -3.4             | 1 41 PM                          | +21                       | 1 56 PM                                  | +16                       | 2 07 PM                          | + 9                       | 2 13 PM                                  | + 2                       |                           |                           |
| <sup>2</sup> Mars    | 1.8              | 10 32 AM                         | +23                       | 10 18 AM                                 | +24                       | 10 01 AM                         | +24                       | 9 45 AM                                  | +23                       |                           |                           |
| <sup>3</sup> Jupiter | -1.4             | 5 31 PM                          | + 0                       | 4 39 PM                                  | + 0                       | 3 44 PM                          | - 1                       | 2 54 PM                                  | - 2                       |                           |                           |
| <sup>4</sup> Saturn  | 1.2              | 5 38 PM                          | + 1                       | 4 42 PM                                  | + 0                       | 3 44 PM                          | + 0                       | 2 50 PM                                  | - 1                       |                           |                           |

Footnotes indicate near proximity of a planet to a star in time of transit and declination.

For reduction of time of transit from the Greenwich mean time to the local mean time at the longitude of the station, see table of Sidereal Conversions, page 27.

STAR TABLES, MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME

| No.                  | Mag.             |                                        |                                       |                                        |                      |                                         |                      |                                         |                      | Transit          |                     |
|----------------------|------------------|----------------------------------------|---------------------------------------|----------------------------------------|----------------------|-----------------------------------------|----------------------|-----------------------------------------|----------------------|------------------|---------------------|
|                      |                  | Transit                                | Decl.                                 | Transit                                | Decl.                | Transit                                 | Decl.                | Transit                                 | Decl.                | Subtract         |                     |
|                      |                  | Sept. 1                                |                                       | Sept. 16                               |                      | Oct. 1                                  |                      | Oct. 16                                 |                      | for day of month |                     |
| 1- 1                 | 2.2              | <sup>h</sup> <sup>m</sup><br>1 26.9 AM | <sup>°</sup> <sup>'</sup><br>+28 59.3 | <sup>h</sup> <sup>m</sup><br>0 28.0 AM | <sup>'</sup><br>59.4 | <sup>h</sup> <sup>m</sup><br>11 25.0 PM | <sup>'</sup><br>59.4 | <sup>h</sup> <sup>m</sup><br>10 26.1 PM | <sup>'</sup><br>59.5 | <sup>1</sup>     | <sup>m</sup><br>0.0 |
| Sept. 23             |                  |                                        |                                       | { 0 00.4 AM }<br>{ 11 56.5 PM }        |                      |                                         |                      |                                         |                      | 2                | 3.9                 |
| 2                    | 2.9              | 1 44.3                                 | -77 21.4                              | 0 45.3 AM                              | 21.4                 | 11 42.4 PM                              | 21.5                 | 10 43.4                                 | 21.6                 | 3                | 7.9                 |
| Sept. 27             |                  |                                        |                                       | { 0 02.1 AM }<br>{ 11 58.1 PM }        |                      |                                         |                      |                                         |                      | 4                | 11.8                |
| 3- 4                 | 2.2              | 2 02.1                                 | -18 05.2                              | 1 03.1 AM                              | 05.2                 | 0 04.1 AM                               | 05.2                 | 11 01.2 PM                              | 05.2                 | 5                | 15.7                |
| Oct. 2               |                  |                                        |                                       |                                        |                      | { 0 00.2 AM }<br>{ 11 56.2 PM }         |                      |                                         |                      | 6                | 19.7                |
| 4                    | 2.1              | 3 33.3                                 | +89 10.5                              | 2 34.6                                 | 10.6                 | 1 35.8 AM                               | 10.6                 | 0 37.0 AM                               | 10.7                 | 7                | 23.6                |
| Oct. 25              |                  |                                        |                                       |                                        |                      |                                         |                      | { 0 01.7 AM }<br>{ 11 57.7 PM }         |                      | 8                | 27.5                |
| 5- 6                 | 2.2              | 3 25.3                                 | +23 22.5                              | 2 26.3                                 | 22.5                 | 1 27.4                                  | 22.6                 | 0 28.4 AM                               | 22.6                 | 9                | 31.5                |
| Oct. 23              |                  |                                        |                                       |                                        |                      |                                         |                      | { 0 00.8 AM }<br>{ 11 56.9 PM }         |                      | 10               | 35.4                |
| 6-10                 | 1.1              | 5 53.6                                 | +16 28.3                              | 4 54.6                                 | 28.4                 | 3 55.7                                  | 28.4                 | 2 56.7 AM                               | 28.4                 | 11               | 39.3                |
| 7-11                 | 0.3              | 6 32.3                                 | - 8 13.2                              | 5 33.3                                 | 13.2                 | 4 34.3                                  | 13.2                 | 3 35.4                                  | 13.2                 | 12               | 43.2                |
| 8-12                 | 0.2              | 6 33.9                                 | +45 58.6                              | 5 35.0                                 | 58.6                 | 4 36.0                                  | 58.6                 | 3 37.0                                  | 58.7                 | 13               | 47.2                |
| 9-16                 | 0.5 <sub>v</sub> | 7 12.7                                 | + 7 24.3                              | 6 13.7                                 | 24.3                 | 5 14.8                                  | 24.3                 | 4 15.8                                  | 24.3                 | 14               | 51.1                |
| 10-17                | -0.9             | 7 42.0                                 | -52 40.9                              | 6 43.0                                 | 40.8                 | 5 44.0                                  | 40.8                 | 4 45.1                                  | 40.9                 | 15               | 55.0                |
| 11-18                | -1.6             | 8 02.7                                 | -16 41.3                              | 7 03.7                                 | 41.2                 | 6 04.8                                  | 41.2                 | 5 05.8                                  | 41.3                 | 16               | 0.0                 |
| 12-20                | 0.5              | 8 56.6                                 | + 5 16.5                              | 7 57.6                                 | 16.5                 | 6 58.6                                  | 16.5                 | 5 59.7                                  | 16.4                 | 17               | 3.9                 |
| 13-21                | 1.2              | 9 02.4 <sup>2</sup>                    | +28 04.3                              | 8 03.4 <sup>2</sup>                    | 04.3                 | 7 04.5                                  | 04.2                 | 6 05.5                                  | 04.2                 | 18               | 7.9                 |
| 14-25                | 2.2              | 10 44.6                                | - 8 34.5                              | 9 45.6                                 | 34.5                 | 8 46.7                                  | 34.5                 | 7 47.7                                  | 34.5                 | 19               | 11.8                |
| 15-26                | 1.3              | 11 25.2 AM                             | +12 03.6                              | 10 26.2 AM                             | 03.6                 | 9 27.3 <sup>2</sup>                     | 03.6                 | 8 28.3 <sup>2</sup>                     | 03.5                 | 20               | 15.7                |
| 16-28                | 2.2              | 1 05.7 PM                              | +14 40.7                              | 12 06.7 PM                             | 40.7                 | 11 07.7 AM                              | 40.7                 | 10 08.7                                 | 40.6                 | 21               | 19.7                |
| 17-33                | 1.2              | 2 41.5 <sup>14</sup> <sup>3</sup>      | -11 03.8                              | 1 42.5 <sup>14</sup> <sup>3</sup>      | 03.8                 | 12 43.5 PM <sup>3</sup> <sup>4</sup>    | 03.7                 | 11 44.6 AM <sup>3</sup> <sup>4</sup>    | 03.7                 | 22               | 23.6                |
| 18-36                | 2.3              | 3 22.8                                 | -36 16.8                              | 2 23.8                                 | 16.7                 | 1 24.8                                  | 16.7                 | 12 25.8 PM                              | 16.7                 | 23               | 27.5                |
| 19-37                | 0.2              | 3 32.0                                 | +19 17.0                              | 2 33.0                                 | 16.9                 | 1 34.0                                  | 16.9                 | 12 35.0                                 | 16.9                 | 24               | 31.5                |
| 20-41                | 2.3              | 4 50.8                                 | +26 46.9                              | 3 51.9                                 | 46.9                 | 2 52.9                                  | 46.9                 | 1 53.9                                  | 46.8                 | 25               | 35.4                |
| 21-42                | 1.2              | 5 45.1                                 | -26 23.5                              | 4 46.1                                 | 23.5                 | 3 47.1 <sup>1</sup>                     | 23.5                 | 2 48.1 <sup>1</sup>                     | 23.4                 | 26               | 39.3                |
| 22-46                | 2.1              | 6 50.7                                 | +12 34.6                              | 5 51.7                                 | 34.6                 | 4 52.7                                  | 34.6                 | 3 53.8                                  | 34.6                 | 27               | 43.2                |
| 23-49                | 0.1              | 7 52.8                                 | +38 46.3                              | 6 53.8                                 | 46.3                 | 5 54.8                                  | 46.3                 | 4 55.8                                  | 46.3                 | 28               | 47.2                |
| 24-50                | 2.1              | 8 10.5                                 | -26 19.2                              | 7 11.5                                 | 19.2                 | 6 12.6                                  | 19.2                 | 5 13.6                                  | 19.2                 | 29               | 51.1                |
| 25-51                | 0.9              | 9 06.1                                 | + 8 49.3                              | 8 07.2                                 | 49.3                 | 7 08.2                                  | 49.3                 | 6 09.2                                  | 49.3                 | 30               | 55.0                |
| 26-54                | 2.5              | 10 59.2 PM                             | + 9 47.5                              | 10 00.3                                | 47.5                 | 9 01.3                                  | 47.6                 | 8 02.3                                  | 47.6                 | 31               | 59.0                |
| 27-56                | 1.3              | 0 16.3 AM                              | -29 43.1                              | 11 13.4                                | 43.2                 | 10 14.4                                 | 43.2                 | 9 15.5                                  | 43.2                 |                  |                     |
| Sept. 5              |                  | { 0 00.6 AM }<br>{ 11 56.7 PM }        |                                       |                                        |                      |                                         |                      |                                         |                      |                  |                     |
| 28-57                | 2.6              | 0 23.5 AM                              | +15 06.4                              | 11 20.6 PM                             | 06.5                 | 10 21.6 PM                              | 06.5                 | 9 22.6 PM                               | 06.5                 |                  |                     |
| Sept. 6              |                  | { 0 03.8 AM }<br>{ 11 59.9 PM }        |                                       |                                        |                      |                                         |                      |                                         |                      |                  |                     |
| <sup>1</sup> Venus   | -3.6             | 2 19 PM                                | - 6                                   | 2 25 PM                                | -14                  | 2 34 PM                                 | -20                  | 2 45 PM                                 | -24                  |                  |                     |
| <sup>2</sup> Mars    | 1.7              | 9 26 AM                                | +21                                   | 9 06 AM                                | +19                  | 8 44 AM                                 | +17                  | 8 21 AM                                 | +14                  |                  |                     |
| <sup>3</sup> Jupiter | -1.2             | 2 03 PM                                | - 4                                   | 1 15 PM                                | - 5                  | 12 27 PM                                | - 6                  | 11 41 AM                                | - 7                  |                  |                     |
| <sup>4</sup> Saturn  | 1.0              | 1 53 PM                                | - 1                                   | 1 00 PM                                | - 2                  | 12 08 PM                                | - 3                  | 11 16 AM                                | - 4                  |                  |                     |

Footnotes indicate near proximity of a planet to a star in time of transit and declination.

For time of transit subsequent to a star's double transit and until the next tabulated date, subtract for the number of days counting from the second transit of that date. All other interpolations may be taken directly by reference to the day of the month.

STAR TABLES, MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME

| No.                  | Mag. |                                   |                           |                                              |              |                                              |              |                                              |              | Transit                         |              |
|----------------------|------|-----------------------------------|---------------------------|----------------------------------------------|--------------|----------------------------------------------|--------------|----------------------------------------------|--------------|---------------------------------|--------------|
|                      |      | Transit                           | Decl.                     | Transit                                      | Decl.        | Transit                                      | Decl.        | Transit                                      | Decl.        | Subtract<br>for day<br>of month |              |
|                      |      | Nov. 1                            |                           | Nov. 16                                      |              | Dec. 1                                       |              | Dec. 16                                      |              |                                 |              |
|                      |      | <sup>h</sup> <sup>m</sup>         | <sup>°</sup> <sup>'</sup> | <sup>h</sup> <sup>m</sup>                    | <sup>'</sup> | <sup>h</sup> <sup>m</sup>                    | <sup>'</sup> | <sup>h</sup> <sup>m</sup>                    | <sup>'</sup> |                                 | <sup>m</sup> |
| 1- 1                 | 2.2  | 9 23.2 PM                         | +28 59.5                  | 8 24.2 PM                                    | 59.5         | 7 25.2 PM                                    | 59.5         | 6 26.2 PM                                    | 59.5         | 1                               | 0.0          |
| 2                    | 2.9  | 9 40.5                            | -77 21.7                  | 8 41.5                                       | 21.7         | 7 42.5                                       | 21.8         | 6 43.5                                       | 21.8         | 2                               | 3.9          |
| 3- 4                 | 2.2  | 9 58.3                            | -18 05.2                  | 8 59.3                                       | 05.3         | 8 00.3                                       | 05.3         | 7 01.3                                       | 05.3         | 3                               | 7.9          |
| 4                    | 2.1  | 11 30.3                           | +89 10.8                  | 10 31.3                                      | 10.9         | 9 32.2                                       | 11.0         | 8 33.0                                       | 11.1         | 4                               | 11.8         |
| 5- 6                 | 2.2  | 11 21.5 PM                        | +23 22.6                  | 10 22.6 PM                                   | 22.6         | 9 23.6                                       | 22.6         | 8 24.6                                       | 22.7         | 5                               | 15.7         |
| 6-10                 | 1.1  | 1 53.8 AM                         | +16 28.4                  | 0 54.8 AM<br>{ 0 03.7 AM }<br>{ 11 59.8 PM } | 28.4         | 11 51.9 PM                                   | 28.4         | 10 52.9                                      | 28.4         | 6                               | 19.7         |
| Nov. 29              |      |                                   |                           |                                              |              |                                              |              |                                              |              | 7                               | 23.6         |
| 7-11                 | 0.3  | 2 32.5                            | - 8 13.3                  | 1 33.5 AM                                    | 13.3         | 0 34.5 AM<br>{ 0 03.1 AM }<br>{ 11 59.1 PM } | 13.3         | 11 31.6                                      | 13.4         | 8                               | 27.5         |
| Dec. 9               |      |                                   |                           |                                              |              |                                              |              |                                              |              | 9                               | 31.5         |
| 8-12                 | 0.2  | 2 34.1                            | +45 58.7                  | 1 35.2                                       | 58.7         | 0 36.2 AM<br>{ 0 00.8 AM }<br>{ 11 56.9 PM } | 58.8         | 11 33.3 PM                                   | 58.8         | 10                              | 35.4         |
| Dec. 10              |      |                                   |                           |                                              |              |                                              |              |                                              |              | 11                              | 39.3         |
| 9-16                 | 0.5v | 3 12.9                            | + 7 24.3                  | 2 13.9                                       | 24.3         | 1 14.9 AM                                    | 24.2         | 0 16.0 AM<br>{ 0 00.2 AM }<br>{ 11 56.3 PM } | 24.2         | 12                              | 43.2         |
| Dec. 20              |      |                                   |                           |                                              |              |                                              |              |                                              |              | 13                              | 47.2         |
| 10-17                | -0.9 | 3 42.2                            | -52 40.9                  | 2 43.2                                       | 41.0         | 1 44.2                                       | 41.0         | 0 45.3 AM<br>{ 0 02.0 AM }<br>{ 11 58.1 PM } | 41.1         | 14                              | 51.1         |
| Dec. 27              |      |                                   |                           |                                              |              |                                              |              |                                              |              | 15                              | 55.0         |
| 11-18                | -1.6 | 4 02.9                            | -16 41.3                  | 3 03.9                                       | 41.3         | 2 05.0                                       | 41.4         | 1 06.0 AM                                    | 41.4         | 16                              | 0.0          |
| 12-20                | 0.5  | 4 56.8                            | + 5 16.4                  | 3 57.8                                       | 16.4         | 2 58.8                                       | 16.3         | 1 59.8                                       | 16.3         | 17                              | 3.9          |
| 13-21                | 1.2  | 5 02.6                            | +28 04.2                  | 4 03.6                                       | 04.2         | 3 04.6                                       | 04.2         | 2 05.7                                       | 04.2         | 18                              | 7.9          |
| 14-25                | 2.2  | 6 44.8                            | - 8 34.6                  | 5 45.8                                       | 34.6         | 4 46.9                                       | 34.6         | 3 47.9                                       | 34.7         | 19                              | 11.8         |
| 15-26                | 1.3  | 7 25.4 <sup>2</sup>               | +12 03.5                  | 6 26.4 <sup>2</sup>                          | 03.5         | 5 27.4                                       | 03.4         | 4 28.5                                       | 03.4         | 20                              | 15.7         |
| 16-28                | 2.2  | 9 05.8 <sup>2</sup>               | +14 40.6                  | 8 06.9 <sup>2</sup>                          | 40.5         | 7 07.9 <sup>2</sup>                          | 40.5         | 6 08.9                                       | 40.4         | 21                              | 19.7         |
| 17-33                | 1.2  | 10 41.7 <sup>3</sup> <sup>4</sup> | -11 03.8                  | 9 42.7 <sup>3</sup> <sup>4</sup>             | 03.8         | 8 43.7 <sup>3</sup> <sup>4</sup>             | 03.8         | 7 44.7 <sup>3</sup> <sup>4</sup>             | 03.9         | 22                              | 23.6         |
| 18-36                | 2.3  | 11 22.9                           | -36 16.6                  | 10 23.9                                      | 16.6         | 9 25.0                                       | 16.6         | 8 26.0                                       | 16.6         | 23                              | 27.5         |
| 19-37                | 0.2  | 11 32.1 AM                        | +19 16.8                  | 10 33.1                                      | 16.7         | 9 34.2                                       | 16.7         | 8 35.2                                       | 16.6         | 24                              | 31.5         |
| 20-41                | 2.3  | 12 51.0 PM                        | +26 46.8                  | 11 52.0 AM                                   | 46.7         | 10 53.0                                      | 46.6         | 9 54.1                                       | 46.5         | 25                              | 35.4         |
| 21-42                | 1.2  | 1 45.2 <sup>1</sup>               | -26 23.4                  | 12 46.2 PM                                   | 23.4         | 11 47.3 AM                                   | 23.4         | 10 48.3                                      | 23.4         | 26                              | 39.3         |
| 22-46                | 2.1  | 2 50.8                            | +12 34.6                  | 1 51.9                                       | 34.5         | 12 52.9 PM                                   | 34.5         | 11 53.9 AM                                   | 34.4         | 27                              | 43.2         |
| 23-49                | 0.1  | 3 52.9                            | +38 46.3                  | 2 53.9                                       | 46.2         | 1 54.9                                       | 46.2         | 12 56.0 PM                                   | 46.1         | 28                              | 47.2         |
| 24-50                | 2.1  | 4 10.7 <sup>1</sup>               | -26 19.2                  | 3 11.7 <sup>1</sup>                          | 19.2         | 2 12.7 <sup>1</sup>                          | 19.2         | 1 13.7                                       | 19.2         | 29                              | 51.1         |
| 25-51                | 0.9  | 5 06.3                            | + 8 49.3                  | 4 07.3                                       | 49.3         | 3 08.3                                       | 49.3         | 2 09.3                                       | 49.3         | 30                              | 55.0         |
| 26-54                | 2.5  | 6 59.4                            | + 9 47.6                  | 6 00.4                                       | 47.6         | 5 01.4                                       | 47.5         | 4 02.4                                       | 47.5         | 31                              | 59.0         |
| 27-56                | 1.3  | 8 12.5                            | -29 43.3                  | 7 13.6                                       | 43.3         | 6 14.6                                       | 43.3         | 5 15.6                                       | 43.3         |                                 |              |
| 28-57                | 2.6  | 8 19.7 PM                         | +15 06.5                  | 7 20.8 PM                                    | 06.5         | 6 21.8 PM                                    | 06.5         | 5 22.8 PM                                    | 06.5         |                                 |              |
|                      |      |                                   |                           |                                              |              |                                              |              |                                              |              |                                 |              |
| <sup>1</sup> Venus   | -4.2 | 2 58 PM                           | -27                       | 3 07 PM                                      | -26          | 3 07 PM                                      | -24          | 2 49 PM                                      | -20          |                                 |              |
| <sup>2</sup> Mars    | 1.3  | 7 53 AM                           | +11                       | 7 26 AM                                      | + 8          | 6 56 AM                                      | + 5          | 6 25 AM                                      | + 2          |                                 |              |
| <sup>3</sup> Jupiter | -1.3 | 10 51 AM                          | - 9                       | 10 03 AM                                     | -10          | 9 16 AM                                      | -11          | 8 27 AM                                      | -12          |                                 |              |
| <sup>4</sup> Saturn  | 1.0  | 10 20 AM                          | - 4                       | 9 27 AM                                      | - 5          | 8 34 AM                                      | - 5          | 7 40 AM                                      | - 6          |                                 |              |

Footnotes indicate near proximity of a planet to a star in time of transit and declination.

For reduction of time of transit from the Greenwich mean time to the local mean time at the longitude of the station, see table of Sidereal Conversions, page 27.

| Mean<br>Time<br>Hour<br>Angle | AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1981 |      |      |      |      |      |      |      |      |      |      |  | CORR. TO AZIMUTH            |        |        |
|-------------------------------|---------------------------------------------|------|------|------|------|------|------|------|------|------|------|--|-----------------------------|--------|--------|
|                               | Mean Declination + 89° 10' 50"              |      |      |      |      |      |      |      |      |      |      |  | Add for<br>Decl. + 89°      |        |        |
|                               |                                             |      |      |      |      |      |      |      |      |      |      |  | 10'40"                      | 10'30" | 10'20" |
|                               | Latitude                                    |      |      |      |      |      |      |      |      |      |      |  | Subtract for<br>Decl. + 89° |        |        |
|                               | 10°                                         | 12°  | 14°  | 16°  | 18°  | 20°  | 22°  | 24°  | 26°  | 28°  | 30°  |  | 11'00"                      | 11'10" | 11'20" |
| h m                           | /                                           | /    | /    | /    | /    | /    | /    | /    | /    | /    | /    |  | /                           | /      | /      |
| 0 00.0                        | 0.0                                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |  | 0.0                         | 0.0    | 0.0    |
| 0 10.0                        | 2.2                                         | 2.2  | 2.2  | 2.2  | 2.3  | 2.3  | 2.3  | 2.4  | 2.4  | 2.4  | 2.5  |  | 0.0                         | 0.0    | 0.0    |
| 19.9                          | 4.4                                         | 4.4  | 4.4  | 4.5  | 4.5  | 4.6  | 4.6  | 4.7  | 4.8  | 4.9  | 5.0  |  | 0.0                         | 0.0    | 0.0    |
| 29.9                          | 6.5                                         | 6.6  | 6.6  | 6.7  | 6.8  | 6.9  | 7.0  | 7.1  | 7.2  | 7.3  | 7.5  |  | 0.0                         | 0.0    | 0.1    |
| 0 39.9                        | 8.7                                         | 8.8  | 8.8  | 8.9  | 9.0  | 9.1  | 9.3  | 9.4  | 9.6  | 9.7  | 9.9  |  | 0.0                         | 0.1    | 0.1    |
| 49.9                          | 10.8                                        | 10.9 | 11.0 | 11.1 | 11.2 | 11.4 | 11.5 | 11.7 | 11.9 | 12.1 | 12.4 |  | 0.0                         | 0.1    | 0.1    |
| 59.8                          | 13.0                                        | 13.0 | 13.2 | 13.3 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.5 | 14.8 |  | 0.0                         | 0.1    | 0.1    |
| 1 09.8                        | 15.0                                        | 15.2 | 15.3 | 15.4 | 15.6 | 15.8 | 16.0 | 16.3 | 16.6 | 16.9 | 17.2 |  | 0.1                         | 0.1    | 0.2    |
| 19.8                          | 17.1                                        | 17.2 | 17.4 | 17.6 | 17.8 | 18.0 | 18.2 | 18.5 | 18.8 | 19.2 | 19.6 |  | 0.1                         | 0.1    | 0.2    |
| 29.8                          | 19.2                                        | 19.3 | 19.5 | 19.6 | 19.9 | 20.1 | 20.4 | 20.7 | 21.1 | 21.5 | 21.9 |  | 0.1                         | 0.1    | 0.2    |
| 1 39.7                        | 21.1                                        | 21.3 | 21.5 | 21.7 | 21.9 | 22.2 | 22.5 | 22.9 | 23.3 | 23.7 | 24.2 |  | 0.1                         | 0.2    | 0.2    |
| 49.7                          | 23.1                                        | 23.3 | 23.5 | 23.7 | 24.0 | 24.3 | 24.6 | 25.0 | 25.4 | 25.9 | 26.4 |  | 0.1                         | 0.2    | 0.2    |
| 59.7                          | 25.0                                        | 25.2 | 25.4 | 25.7 | 26.0 | 26.3 | 26.6 | 27.1 | 27.5 | 28.0 | 28.6 |  | 0.1                         | 0.2    | 0.3    |
| 2 09.6                        | 26.9                                        | 27.1 | 27.3 | 27.6 | 27.9 | 28.2 | 28.6 | 29.1 | 29.6 | 30.1 | 30.7 |  | 0.1                         | 0.2    | 0.3    |
| 19.6                          | 28.7                                        | 28.9 | 29.2 | 29.4 | 29.8 | 30.1 | 30.6 | 31.0 | 31.6 | 32.1 | 32.8 |  | 0.1                         | 0.2    | 0.3    |
| 29.6                          | 30.5                                        | 30.7 | 30.9 | 31.2 | 31.6 | 32.0 | 32.4 | 32.9 | 33.5 | 34.1 | 34.8 |  | 0.1                         | 0.2    | 0.3    |
| 2 39.6                        | 32.2                                        | 32.4 | 32.7 | 33.0 | 33.4 | 33.8 | 34.2 | 34.8 | 35.4 | 36.0 | 36.7 |  | 0.1                         | 0.2    | 0.3    |
| 49.5                          | 33.8                                        | 34.0 | 34.3 | 34.7 | 35.0 | 35.5 | 36.0 | 36.5 | 37.1 | 37.8 | 38.6 |  | 0.1                         | 0.2    | 0.4    |
| 59.5                          | 35.4                                        | 35.6 | 35.9 | 36.3 | 36.7 | 37.1 | 37.7 | 38.2 | 38.9 | 39.6 | 40.4 |  | 0.1                         | 0.3    | 0.4    |
| 3 09.5                        | 36.9                                        | 37.1 | 37.5 | 37.8 | 38.2 | 38.7 | 39.3 | 39.9 | 40.5 | 41.3 | 42.1 |  | 0.1                         | 0.3    | 0.4    |
| 19.5                          | 38.3                                        | 38.6 | 38.9 | 39.3 | 39.7 | 40.2 | 40.8 | 41.4 | 42.1 | 42.9 | 43.7 |  | 0.1                         | 0.3    | 0.4    |
| 29.4                          | 39.7                                        | 40.0 | 40.3 | 40.7 | 41.1 | 41.6 | 42.2 | 42.9 | 43.6 | 44.4 | 45.3 |  | 0.1                         | 0.3    | 0.4    |
| 3 39.4                        | 41.0                                        | 41.2 | 41.6 | 42.0 | 42.5 | 43.0 | 43.6 | 44.2 | 45.0 | 45.8 | 46.7 |  | 0.1                         | 0.3    | 0.4    |
| 49.4                          | 42.2                                        | 42.5 | 42.8 | 43.2 | 43.7 | 44.3 | 44.9 | 45.5 | 46.3 | 47.2 | 48.1 |  | 0.2                         | 0.3    | 0.5    |
| 59.3                          | 43.3                                        | 43.6 | 44.0 | 44.4 | 44.9 | 45.4 | 46.1 | 46.8 | 47.5 | 48.4 | 49.4 |  | 0.2                         | 0.3    | 0.5    |
| 4 09.3                        | 44.3                                        | 44.6 | 45.0 | 45.5 | 46.0 | 46.5 | 47.2 | 47.9 | 48.7 | 49.6 | 50.6 |  | 0.2                         | 0.3    | 0.5    |
| 19.3                          | 45.3                                        | 45.6 | 46.0 | 46.4 | 46.9 | 47.5 | 48.2 | 48.9 | 49.7 | 50.6 | 51.6 |  | 0.2                         | 0.3    | 0.5    |
| 29.3                          | 46.2                                        | 46.5 | 46.9 | 47.3 | 47.8 | 48.4 | 49.1 | 49.8 | 50.7 | 51.6 | 52.6 |  | 0.2                         | 0.3    | 0.5    |
| 4 39.2                        | 47.0                                        | 47.3 | 47.7 | 48.1 | 48.7 | 49.3 | 49.9 | 50.7 | 51.5 | 52.5 | 53.5 |  | 0.2                         | 0.3    | 0.5    |
| 49.2                          | 47.7                                        | 48.0 | 48.4 | 48.8 | 49.4 | 50.0 | 50.7 | 51.4 | 52.3 | 53.2 | 54.3 |  | 0.2                         | 0.3    | 0.5    |
| 59.2                          | 48.3                                        | 48.6 | 49.0 | 49.5 | 50.0 | 50.6 | 51.3 | 52.1 | 52.9 | 53.9 | 55.0 |  | 0.2                         | 0.3    | 0.5    |
| 5 09.2                        | 48.8                                        | 49.1 | 49.5 | 50.0 | 50.5 | 51.1 | 51.8 | 52.6 | 53.5 | 54.5 | 55.5 |  | 0.2                         | 0.3    | 0.5    |
| 19.1                          | 49.2                                        | 49.5 | 49.9 | 50.4 | 51.0 | 51.6 | 52.3 | 53.1 | 53.9 | 54.9 | 56.0 |  | 0.2                         | 0.3    | 0.5    |
| 29.1                          | 49.5                                        | 49.9 | 50.3 | 50.7 | 51.3 | 51.9 | 52.6 | 53.4 | 54.3 | 55.3 | 56.3 |  | 0.2                         | 0.4    | 0.5    |
| 5 39.1                        | 49.7                                        | 50.1 | 50.5 | 51.0 | 51.5 | 52.1 | 52.9 | 53.6 | 54.5 | 55.5 | 56.6 |  | 0.2                         | 0.4    | 0.5    |
| 49.0                          | 49.9                                        | 50.2 | 50.6 | 51.1 | 51.7 | 52.3 | 53.0 | 53.8 | 54.7 | 55.6 | 56.7 |  | 0.2                         | 0.4    | 0.5    |
| 57.1                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 56.8 |  | 0.2                         | 0.4    | 0.6    |
| 5 57.3                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 55.7 | ...  |  | 0.2                         | 0.4    | 0.6    |
| 57.4                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 54.7 | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 57.6                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | 53.8 | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.5    |
| 5 57.7                        | ...                                         | ...  | ...  | ...  | ...  | ...  | 53.0 | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.5    |
| 57.8                          | ...                                         | ...  | ...  | ...  | ...  | 52.3 | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.5    |
| 56.0                          | ...                                         | ...  | ...  | ...  | 51.7 | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.5    |
| 5 58.1                        | ...                                         | ...  | ...  | 51.1 | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.3    | 0.5    |
| 58.2                          | ...                                         | ...  | 50.7 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.3    | 0.5    |
| 58.3                          | ...                                         | 50.3 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.3    | 0.5    |
| 5 58.4                        | 49.9                                        | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.3    | 0.5    |

See footnote pages 18 and 19 for equation to be employed when values in seconds are required.

| Mean<br>Time<br>Hour<br>Angle | AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1981 |      |      |      |      |      |      |      |      |      |      |     | CORR. TO AZIMUTH            |        |        |
|-------------------------------|---------------------------------------------|------|------|------|------|------|------|------|------|------|------|-----|-----------------------------|--------|--------|
|                               | Mean Declination + 89° 10' 50"              |      |      |      |      |      |      |      |      |      |      |     | Add for<br>Decl. + 89°      |        |        |
|                               |                                             |      |      |      |      |      |      |      |      |      |      |     | 10'40"                      | 10'30" | 10'20" |
|                               | Latitude                                    |      |      |      |      |      |      |      |      |      |      |     | Subtract for<br>Decl. + 89° |        |        |
|                               |                                             |      |      |      |      |      |      |      |      |      |      |     | 11'00"                      | 11'10" | 11'20" |
| h m                           | /                                           | /    | /    | /    | /    | /    | /    | /    | /    | /    | /    |     | /                           | /      | /      |
| 5 57.1                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 56.8 |     | 0.2                         | 0.4    | 0.6    |
| 57.3                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 55.7 | ... | 0.2                         | 0.4    | 0.6    |
| 57.4                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 54.7 | ...  | ... | 0.2                         | 0.4    | 0.6    |
| 5 57.6                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | 53.8 | ...  | ...  | ...  |     | 0.2                         | 0.4    | 0.5    |
| 57.7                          | ...                                         | ...  | ...  | ...  | ...  | ...  | 53.0 | ...  | ...  | ...  | ...  | ... | 0.2                         | 0.4    | 0.5    |
| 57.8                          | ...                                         | ...  | ...  | ...  | ...  | 52.3 | ...  | ...  | ...  | ...  | ...  | ... | 0.2                         | 0.4    | 0.5    |
| 5 58.0                        | ...                                         | ...  | ...  | ...  | 51.7 | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.2                         | 0.4    | 0.5    |
| 58.1                          | ...                                         | ...  | ...  | 51.1 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.2                         | 0.3    | 0.5    |
| 58.2                          | ...                                         | ...  | 50.7 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.2                         | 0.3    | 0.5    |
| 5 58.3                        | ...                                         | 50.3 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.2                         | 0.3    | 0.5    |
| 58.4                          | 49.9                                        | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.2                         | 0.3    | 0.5    |
| 59.0                          | 49.9                                        | 50.3 | 50.7 | 51.1 | 51.7 | 52.3 | 53.0 | 53.8 | 54.7 | 55.7 | 56.8 | ... | 0.2                         | 0.4    | 0.5    |
| 6 09.0                        | 49.9                                        | 50.2 | 50.6 | 51.1 | 51.6 | 52.3 | 53.0 | 53.8 | 54.6 | 55.6 | 56.7 | ... | 0.2                         | 0.4    | 0.5    |
| 19.0                          | 49.7                                        | 50.1 | 50.5 | 50.9 | 51.5 | 52.1 | 52.8 | 53.6 | 54.5 | 55.4 | 56.5 | ... | 0.2                         | 0.4    | 0.5    |
| 28.9                          | 49.5                                        | 49.8 | 50.2 | 50.7 | 51.2 | 51.8 | 52.5 | 53.3 | 54.2 | 55.2 | 56.2 | ... | 0.2                         | 0.4    | 0.5    |
| 6 38.9                        | 49.1                                        | 49.5 | 49.9 | 50.3 | 50.9 | 51.5 | 52.2 | 52.9 | 53.8 | 54.8 | 55.8 | ... | 0.2                         | 0.3    | 0.5    |
| 48.9                          | 48.7                                        | 49.0 | 49.4 | 49.9 | 50.4 | 51.0 | 51.7 | 52.5 | 53.3 | 54.3 | 55.3 | ... | 0.2                         | 0.3    | 0.5    |
| 58.9                          | 48.2                                        | 48.5 | 48.9 | 49.4 | 49.9 | 50.5 | 51.1 | 51.9 | 52.7 | 53.7 | 54.7 | ... | 0.2                         | 0.3    | 0.5    |
| 7 08.8                        | 47.6                                        | 47.9 | 48.3 | 48.7 | 49.2 | 49.8 | 50.5 | 51.2 | 52.1 | 53.0 | 54.0 | ... | 0.2                         | 0.3    | 0.5    |
| 18.8                          | 46.9                                        | 47.2 | 47.6 | 48.0 | 48.5 | 49.1 | 49.7 | 50.5 | 51.3 | 52.2 | 53.2 | ... | 0.2                         | 0.3    | 0.5    |
| 28.8                          | 46.1                                        | 46.4 | 46.8 | 47.2 | 47.7 | 48.2 | 48.9 | 49.6 | 50.4 | 51.3 | 52.3 | ... | 0.2                         | 0.3    | 0.5    |
| 7 38.7                        | 45.2                                        | 45.5 | 45.9 | 46.3 | 46.8 | 47.3 | 47.9 | 48.6 | 49.4 | 50.3 | 51.3 | ... | 0.2                         | 0.3    | 0.5    |
| 48.7                          | 44.2                                        | 44.5 | 44.9 | 45.3 | 45.8 | 46.3 | 46.9 | 47.6 | 48.4 | 49.2 | 50.2 | ... | 0.2                         | 0.3    | 0.5    |
| 58.7                          | 43.2                                        | 43.5 | 43.8 | 44.2 | 44.7 | 45.2 | 45.8 | 46.5 | 47.2 | 48.0 | 49.0 | ... | 0.2                         | 0.3    | 0.5    |
| 8 08.7                        | 42.1                                        | 42.3 | 42.7 | 43.0 | 43.5 | 44.0 | 44.6 | 45.2 | 46.0 | 46.8 | 47.7 | ... | 0.1                         | 0.3    | 0.4    |
| 18.6                          | 40.8                                        | 41.1 | 41.4 | 41.8 | 42.2 | 42.7 | 43.3 | 43.9 | 44.6 | 45.4 | 46.3 | ... | 0.1                         | 0.3    | 0.4    |
| 28.6                          | 39.5                                        | 39.8 | 40.1 | 40.5 | 40.9 | 41.4 | 41.9 | 42.5 | 43.2 | 44.0 | 44.8 | ... | 0.1                         | 0.3    | 0.4    |
| 8 38.6                        | 38.2                                        | 38.4 | 38.7 | 39.1 | 39.5 | 39.9 | 40.5 | 41.1 | 41.7 | 42.5 | 43.3 | ... | 0.1                         | 0.3    | 0.4    |
| 48.6                          | 36.7                                        | 37.0 | 37.3 | 37.6 | 38.0 | 38.4 | 38.9 | 39.5 | 40.1 | 40.8 | 41.6 | ... | 0.1                         | 0.3    | 0.4    |
| 58.5                          | 35.2                                        | 35.5 | 35.7 | 36.1 | 36.4 | 36.9 | 37.3 | 37.9 | 38.5 | 39.2 | 39.9 | ... | 0.1                         | 0.2    | 0.4    |
| 9 08.5                        | 33.7                                        | 33.9 | 34.1 | 34.5 | 34.8 | 35.2 | 35.7 | 36.2 | 36.8 | 37.4 | 38.1 | ... | 0.1                         | 0.2    | 0.4    |
| 18.5                          | 32.0                                        | 32.2 | 32.5 | 32.8 | 33.1 | 33.5 | 33.9 | 34.4 | 35.0 | 35.6 | 36.3 | ... | 0.1                         | 0.2    | 0.3    |
| 28.4                          | 30.3                                        | 30.5 | 30.8 | 31.0 | 31.4 | 31.7 | 32.1 | 32.6 | 33.1 | 33.7 | 34.3 | ... | 0.1                         | 0.2    | 0.3    |
| 9 38.4                        | 28.6                                        | 28.8 | 29.0 | 29.2 | 29.5 | 29.9 | 30.3 | 30.7 | 31.2 | 31.7 | 32.3 | ... | 0.1                         | 0.2    | 0.3    |
| 48.4                          | 26.8                                        | 26.9 | 27.1 | 27.4 | 27.7 | 28.0 | 28.4 | 28.8 | 29.2 | 29.7 | 30.3 | ... | 0.1                         | 0.2    | 0.3    |
| 58.4                          | 24.9                                        | 25.1 | 25.3 | 25.5 | 25.7 | 26.0 | 26.4 | 26.8 | 27.2 | 27.7 | 28.2 | ... | 0.1                         | 0.2    | 0.3    |
| 10 08.3                       | 23.0                                        | 23.1 | 23.3 | 23.5 | 23.8 | 24.0 | 24.4 | 24.7 | 25.1 | 25.5 | 26.0 | ... | 0.1                         | 0.2    | 0.2    |
| 18.3                          | 21.1                                        | 21.2 | 21.3 | 21.5 | 21.8 | 22.0 | 22.3 | 22.6 | 23.0 | 23.4 | 23.8 | ... | 0.1                         | 0.1    | 0.2    |
| 28.3                          | 19.1                                        | 19.2 | 19.3 | 19.5 | 19.7 | 19.9 | 20.2 | 20.5 | 20.8 | 21.2 | 21.6 | ... | 0.1                         | 0.1    | 0.2    |
| 10 38.3                       | 17.0                                        | 17.1 | 17.3 | 17.4 | 17.6 | 17.8 | 18.0 | 18.3 | 18.6 | 18.9 | 19.3 | ... | 0.1                         | 0.1    | 0.2    |
| 48.2                          | 15.0                                        | 15.1 | 15.2 | 15.3 | 15.5 | 15.7 | 15.9 | 16.1 | 16.3 | 16.6 | 16.9 | ... | 0.1                         | 0.1    | 0.2    |
| 58.2                          | 12.9                                        | 13.0 | 13.1 | 13.2 | 13.3 | 13.5 | 13.6 | 13.8 | 14.1 | 14.3 | 14.6 | ... | 0.0                         | 0.1    | 0.1    |
| 11 08.2                       | 10.8                                        | 10.8 | 10.9 | 11.0 | 11.1 | 11.3 | 11.4 | 11.6 | 11.8 | 12.0 | 12.2 | ... | 0.0                         | 0.1    | 0.1    |
| 18.1                          | 8.6                                         | 8.7  | 8.8  | 8.8  | 8.9  | 9.0  | 9.2  | 9.3  | 9.4  | 9.6  | 9.8  | ... | 0.0                         | 0.1    | 0.1    |
| 28.1                          | 6.5                                         | 6.5  | 6.6  | 6.6  | 6.7  | 6.8  | 6.9  | 7.0  | 7.1  | 7.2  | 7.4  | ... | 0.0                         | 0.0    | 0.1    |
| 11 38.1                       | 4.3                                         | 4.4  | 4.4  | 4.4  | 4.5  | 4.5  | 4.6  | 4.7  | 4.7  | 4.8  | 4.9  | ... | 0.0                         | 0.0    | 0.0    |
| 48.1                          | 2.2                                         | 2.2  | 2.2  | 2.2  | 2.2  | 2.3  | 2.3  | 2.3  | 2.4  | 2.4  | 2.5  | ... | 0.0                         | 0.0    | 0.0    |
| 58.0                          | 0.0                                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | ... | 0.0                         | 0.0    | 0.0    |

See footnote pages 18 and 19 for equation to be employed when values in seconds are required.

| Mean<br>Time<br>Hour<br>Angle | AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1981 |      |      |      |      |      |      |      |      |      |      |  | CORR. TO AZIMUTH            |        |        |
|-------------------------------|---------------------------------------------|------|------|------|------|------|------|------|------|------|------|--|-----------------------------|--------|--------|
|                               | Mean Declination + 89° 10' 50"              |      |      |      |      |      |      |      |      |      |      |  | Add for<br>Decl. + 89°      |        |        |
|                               |                                             |      |      |      |      |      |      |      |      |      |      |  | 10'40"                      | 10'30" | 10'20" |
|                               | Latitude                                    |      |      |      |      |      |      |      |      |      |      |  | Subtract for<br>Decl. + 89° |        |        |
|                               | 30°                                         | 32°  | 34°  | 36°  | 38°  | 40°  | 42°  | 44°  | 46°  | 48°  | 50°  |  | 11'00"                      | 11'10" | 11'20" |
| h m                           | /                                           | /    | /    | /    | /    | /    | /    | /    | /    | /    | /    |  | /                           | /      | /      |
| 0 00.0                        | 0.0                                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |  | 0.0                         | 0.0    | 0.0    |
| 0 10.0                        | 2.5                                         | 2.6  | 2.6  | 2.7  | 2.8  | 2.8  | 2.9  | 3.0  | 3.1  | 3.3  | 3.4  |  | 0.0                         | 0.0    | 0.0    |
| 19.9                          | 5.0                                         | 5.1  | 5.2  | 5.4  | 5.5  | 5.7  | 5.8  | 6.0  | 6.3  | 6.5  | 6.8  |  | 0.0                         | 0.0    | 0.1    |
| 29.9                          | 7.5                                         | 7.6  | 7.8  | 8.0  | 8.2  | 8.5  | 8.7  | 9.0  | 9.4  | 9.7  | 10.2 |  | 0.0                         | 0.1    | 0.1    |
| 0 39.9                        | 9.9                                         | 10.2 | 10.4 | 10.7 | 11.0 | 11.3 | 11.6 | 12.0 | 12.5 | 13.0 | 13.5 |  | 0.0                         | 0.1    | 0.1    |
| 49.9                          | 12.4                                        | 12.7 | 13.0 | 13.3 | 13.7 | 14.1 | 14.5 | 15.0 | 15.5 | 16.2 | 16.8 |  | 0.0                         | 0.1    | 0.1    |
| 59.8                          | 14.8                                        | 15.1 | 15.5 | 15.9 | 16.3 | 16.8 | 17.3 | 17.9 | 18.6 | 19.3 | 20.1 |  | 0.1                         | 0.1    | 0.2    |
| 1 09.8                        | 17.2                                        | 17.6 | 18.0 | 18.5 | 19.0 | 19.5 | 20.1 | 20.8 | 21.6 | 22.4 | 23.4 |  | 0.1                         | 0.1    | 0.2    |
| 19.8                          | 19.6                                        | 20.0 | 20.5 | 21.0 | 21.6 | 22.2 | 22.9 | 23.7 | 24.6 | 25.5 | 26.6 |  | 0.1                         | 0.2    | 0.2    |
| 29.8                          | 21.9                                        | 22.4 | 22.9 | 23.5 | 24.1 | 24.8 | 25.6 | 26.5 | 27.5 | 28.5 | 29.7 |  | 0.1                         | 0.2    | 0.3    |
| 1 39.7                        | 24.2                                        | 24.7 | 25.3 | 25.9 | 26.6 | 27.4 | 28.3 | 29.3 | 30.3 | 31.5 | 32.8 |  | 0.1                         | 0.2    | 0.3    |
| 49.7                          | 26.4                                        | 27.0 | 27.6 | 28.3 | 29.1 | 30.0 | 30.9 | 32.0 | 33.1 | 34.4 | 35.9 |  | 0.1                         | 0.2    | 0.3    |
| 59.7                          | 28.6                                        | 29.2 | 29.9 | 30.7 | 31.5 | 32.4 | 33.5 | 34.6 | 35.9 | 37.3 | 38.8 |  | 0.1                         | 0.2    | 0.3    |
| 2 09.6                        | 30.7                                        | 31.4 | 32.1 | 32.9 | 33.8 | 34.8 | 35.9 | 37.2 | 38.5 | 40.0 | 41.7 |  | 0.1                         | 0.2    | 0.4    |
| 19.6                          | 32.8                                        | 33.5 | 34.3 | 35.2 | 36.1 | 37.2 | 38.4 | 39.7 | 41.1 | 42.7 | 44.5 |  | 0.1                         | 0.3    | 0.4    |
| 29.6                          | 34.8                                        | 35.5 | 36.4 | 37.3 | 38.3 | 39.4 | 40.7 | 42.1 | 43.6 | 45.3 | 47.2 |  | 0.1                         | 0.3    | 0.4    |
| 2 39.6                        | 36.7                                        | 37.5 | 38.4 | 39.4 | 40.5 | 41.6 | 43.0 | 44.4 | 46.0 | 47.8 | 49.8 |  | 0.1                         | 0.3    | 0.4    |
| 49.5                          | 38.6                                        | 39.4 | 40.4 | 41.4 | 42.5 | 43.7 | 45.1 | 46.7 | 48.3 | 50.2 | 52.3 |  | 0.1                         | 0.3    | 0.4    |
| 59.5                          | 40.4                                        | 41.3 | 42.2 | 43.3 | 44.5 | 45.8 | 47.2 | 48.8 | 50.6 | 52.5 | 54.7 |  | 0.2                         | 0.3    | 0.5    |
| 3 09.5                        | 42.1                                        | 43.0 | 44.0 | 45.1 | 46.4 | 47.7 | 49.2 | 50.9 | 52.7 | 54.8 | 57.0 |  | 0.2                         | 0.3    | 0.5    |
| 19.5                          | 43.7                                        | 44.7 | 45.7 | 46.9 | 48.1 | 49.5 | 51.1 | 52.8 | 54.7 | 56.9 | 59.2 |  | 0.2                         | 0.3    | 0.5    |
| 29.4                          | 45.3                                        | 46.2 | 47.3 | 48.5 | 49.8 | 51.3 | 52.9 | 54.7 | 56.7 | 58.9 | 61.3 |  | 0.2                         | 0.3    | 0.5    |
| 3 39.4                        | 46.7                                        | 47.7 | 48.9 | 50.1 | 51.4 | 52.9 | 54.6 | 56.4 | 58.5 | 60.7 | 63.3 |  | 0.2                         | 0.4    | 0.5    |
| 49.4                          | 48.1                                        | 49.1 | 50.3 | 51.5 | 52.9 | 54.5 | 56.2 | 58.1 | 60.2 | 62.5 | 65.1 |  | 0.2                         | 0.4    | 0.6    |
| 59.3                          | 49.4                                        | 50.4 | 51.6 | 52.9 | 54.3 | 55.9 | 57.7 | 59.6 | 61.8 | 64.1 | 66.8 |  | 0.2                         | 0.4    | 0.6    |
| 4 09.3                        | 50.6                                        | 51.6 | 52.8 | 54.2 | 55.6 | 57.2 | 59.0 | 61.0 | 63.2 | 65.7 | 68.4 |  | 0.2                         | 0.4    | 0.6    |
| 19.3                          | 51.6                                        | 52.7 | 54.0 | 55.3 | 56.8 | 58.5 | 60.3 | 62.3 | 64.5 | 67.0 | 69.8 |  | 0.2                         | 0.4    | 0.6    |
| 29.3                          | 52.6                                        | 53.7 | 55.0 | 56.4 | 57.9 | 59.6 | 61.4 | 63.5 | 65.8 | 68.3 | 71.1 |  | 0.2                         | 0.4    | 0.6    |
| 4 39.2                        | 53.5                                        | 54.6 | 55.9 | 57.3 | 58.9 | 60.6 | 62.4 | 64.5 | 66.8 | 69.4 | 72.3 |  | 0.2                         | 0.4    | 0.6    |
| 49.2                          | 54.3                                        | 55.4 | 56.7 | 58.1 | 59.7 | 61.4 | 63.3 | 65.5 | 67.8 | 70.4 | 73.3 |  | 0.2                         | 0.4    | 0.6    |
| 59.2                          | 55.0                                        | 56.1 | 57.4 | 58.9 | 60.4 | 62.2 | 64.1 | 66.3 | 68.6 | 71.3 | 74.2 |  | 0.2                         | 0.4    | 0.6    |
| 5 09.2                        | 55.5                                        | 56.7 | 58.0 | 59.5 | 61.1 | 62.8 | 64.8 | 66.9 | 69.3 | 72.0 | 74.9 |  | 0.2                         | 0.4    | 0.6    |
| 19.1                          | 56.0                                        | 57.2 | 58.5 | 60.0 | 61.6 | 63.3 | 65.3 | 67.5 | 69.9 | 72.6 | 75.5 |  | 0.2                         | 0.4    | 0.6    |
| 29.1                          | 56.3                                        | 57.5 | 58.9 | 60.3 | 61.9 | 63.7 | 65.7 | 67.9 | 70.3 | 73.0 | 76.0 |  | 0.2                         | 0.4    | 0.6    |
| 5 39.1                        | 56.6                                        | 57.8 | 59.1 | 60.6 | 62.2 | 64.0 | 66.0 | 68.2 | 70.6 | 73.3 | 76.3 |  | 0.2                         | 0.4    | 0.7    |
| 49.0                          | 56.7                                        | 57.9 | 59.3 | 60.7 | 62.4 | 64.2 | 66.1 | 68.3 | 70.8 | 73.5 | 76.5 |  | 0.2                         | 0.4    | 0.7    |
| 55.1                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 76.5 |  | 0.3                         | 0.5    | 0.8    |
| 5 55.4                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 73.5 | ...  |  | 0.2                         | 0.5    | 0.7    |
| 55.6                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 70.8 | ...  | ...  |  | 0.2                         | 0.5    | 0.7    |
| 55.9                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | 68.4 | ...  | ...  | ...  |  | 0.2                         | 0.5    | 0.7    |
| 5 56.1                        | ...                                         | ...  | ...  | ...  | ...  | ...  | 66.2 | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.7    |
| 56.3                          | ...                                         | ...  | ...  | ...  | ...  | 64.2 | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.7    |
| 56.5                          | ...                                         | ...  | ...  | ...  | 62.4 | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 5 56.6                        | ...                                         | ...  | ...  | 60.8 | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 56.8                          | ...                                         | ...  | 59.3 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 57.0                          | ...                                         | 58.0 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 5 57.1                        | 56.8                                        | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |

Note: The equation shown on the opposite page may be employed when values in seconds are required, also for stations beyond the limits of the latitude tabulations, where:

- A = Azimuth angle
- t = Sidereal hour angle
- φ = Latitude of station
- δ = Declination of Polaris

| Mean<br>Time<br>Hour<br>Angle | AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1981 |      |      |      |      |      |      |      |      |      |      |  | CORR. TO AZIMUTH            |        |        |
|-------------------------------|---------------------------------------------|------|------|------|------|------|------|------|------|------|------|--|-----------------------------|--------|--------|
|                               | Mean Declination + 89° 10' 50"              |      |      |      |      |      |      |      |      |      |      |  | Add for<br>Decl. + 89°      |        |        |
|                               |                                             |      |      |      |      |      |      |      |      |      |      |  | 10'40"                      | 10'30" | 10'20" |
|                               | Latitude                                    |      |      |      |      |      |      |      |      |      |      |  | Subtract for<br>Decl. + 89° |        |        |
|                               | 30°                                         | 32°  | 34°  | 36°  | 38°  | 40°  | 42°  | 44°  | 46°  | 48°  | 50°  |  | 11'00"                      | 11'10" | 11'20" |
| h m                           | /                                           | /    | /    | /    | /    | /    | /    | /    | /    | /    | /    |  | /                           | /      | /      |
| 5 55.1                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 76.5 |  | 0.3                         | 0.5    | 0.8    |
| 55.4                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 73.5 | ...  |  | 0.2                         | 0.5    | 0.7    |
| 55.6                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 70.8 | ...  | ...  |  | 0.2                         | 0.5    | 0.7    |
| 5 55.9                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | 68.4 | ...  | ...  | ...  |  | 0.2                         | 0.5    | 0.7    |
| 56.1                          | ...                                         | ...  | ...  | ...  | ...  | ...  | 66.2 | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.7    |
| 56.3                          | ...                                         | ...  | ...  | ...  | ...  | 64.2 | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.7    |
| 5 56.5                        | ...                                         | ...  | ...  | ...  | 62.4 | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 56.6                          | ...                                         | ...  | ...  | 60.8 | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 56.8                          | ...                                         | ...  | 59.3 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 5 57.0                        | ...                                         | 58.0 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 57.1                          | 56.8                                        | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |  | 0.2                         | 0.4    | 0.6    |
| 59.0                          | 56.8                                        | 58.0 | 59.3 | 60.8 | 62.4 | 64.2 | 66.2 | 68.3 | 70.8 | 73.5 | 76.5 |  | 0.2                         | 0.4    | 0.7    |
| 6 09.0                        | 56.7                                        | 57.9 | 59.2 | 60.7 | 62.3 | 64.1 | 66.1 | 68.2 | 70.7 | 73.4 | 76.4 |  | 0.2                         | 0.4    | 0.7    |
| 19.0                          | 56.5                                        | 57.7 | 59.0 | 60.5 | 62.1 | 63.9 | 65.8 | 68.0 | 70.4 | 73.1 | 76.1 |  | 0.2                         | 0.4    | 0.6    |
| 28.9                          | 56.2                                        | 57.4 | 58.7 | 60.2 | 61.8 | 63.5 | 65.5 | 67.6 | 70.0 | 72.7 | 75.7 |  | 0.2                         | 0.4    | 0.6    |
| 6 38.9                        | 55.8                                        | 57.0 | 58.3 | 59.7 | 61.3 | 63.1 | 65.0 | 67.1 | 69.5 | 72.2 | 75.1 |  | 0.2                         | 0.4    | 0.6    |
| 48.9                          | 55.3                                        | 56.5 | 57.8 | 59.2 | 60.8 | 62.5 | 64.4 | 66.5 | 68.9 | 71.5 | 74.4 |  | 0.2                         | 0.4    | 0.6    |
| 58.9                          | 54.7                                        | 55.9 | 57.1 | 58.5 | 60.1 | 61.8 | 63.7 | 65.8 | 68.1 | 70.7 | 73.6 |  | 0.2                         | 0.4    | 0.6    |
| 7 08.8                        | 54.0                                        | 55.1 | 56.4 | 57.8 | 59.3 | 61.0 | 62.9 | 64.9 | 67.2 | 69.7 | 72.6 |  | 0.2                         | 0.4    | 0.6    |
| 18.8                          | 53.2                                        | 54.3 | 55.5 | 56.9 | 58.4 | 60.1 | 61.9 | 63.9 | 66.2 | 68.7 | 71.5 |  | 0.2                         | 0.4    | 0.6    |
| 28.8                          | 52.3                                        | 53.4 | 54.6 | 55.9 | 57.4 | 59.0 | 60.8 | 62.8 | 65.0 | 67.5 | 70.2 |  | 0.2                         | 0.4    | 0.6    |
| 7 38.7                        | 51.3                                        | 52.3 | 53.5 | 54.8 | 56.3 | 57.9 | 59.6 | 61.6 | 63.7 | 66.1 | 68.8 |  | 0.2                         | 0.4    | 0.6    |
| 48.7                          | 50.2                                        | 51.2 | 52.4 | 53.6 | 55.1 | 56.6 | 58.3 | 60.2 | 62.4 | 64.7 | 67.3 |  | 0.2                         | 0.4    | 0.6    |
| 58.7                          | 49.0                                        | 50.0 | 51.1 | 52.4 | 53.7 | 55.3 | 56.9 | 58.8 | 60.8 | 63.1 | 65.7 |  | 0.2                         | 0.4    | 0.6    |
| 8 08.7                        | 47.7                                        | 48.7 | 49.8 | 51.0 | 52.3 | 53.8 | 55.4 | 57.2 | 59.2 | 61.4 | 63.9 |  | 0.2                         | 0.4    | 0.5    |
| 18.6                          | 46.3                                        | 47.2 | 48.3 | 49.5 | 50.8 | 52.2 | 53.8 | 55.5 | 57.5 | 59.6 | 62.0 |  | 0.2                         | 0.4    | 0.5    |
| 28.6                          | 44.8                                        | 45.7 | 46.8 | 47.9 | 49.2 | 50.5 | 52.1 | 53.8 | 55.6 | 57.7 | 60.1 |  | 0.2                         | 0.3    | 0.5    |
| 8 38.6                        | 43.3                                        | 44.2 | 45.2 | 46.2 | 47.5 | 48.8 | 50.3 | 51.9 | 53.7 | 55.7 | 58.0 |  | 0.2                         | 0.3    | 0.5    |
| 48.6                          | 41.6                                        | 42.5 | 43.4 | 44.5 | 45.7 | 46.9 | 48.4 | 49.9 | 51.7 | 53.6 | 55.8 |  | 0.2                         | 0.3    | 0.5    |
| 58.5                          | 39.9                                        | 40.7 | 41.7 | 42.7 | 43.8 | 45.0 | 46.4 | 47.9 | 49.5 | 51.4 | 53.4 |  | 0.2                         | 0.3    | 0.5    |
| 9 08.5                        | 38.1                                        | 38.9 | 39.8 | 40.7 | 41.8 | 43.0 | 44.3 | 45.7 | 47.3 | 49.1 | 51.0 |  | 0.1                         | 0.3    | 0.4    |
| 18.5                          | 36.3                                        | 37.0 | 37.8 | 38.8 | 39.8 | 40.9 | 42.1 | 43.5 | 45.0 | 46.7 | 48.5 |  | 0.1                         | 0.3    | 0.4    |
| 28.4                          | 34.3                                        | 35.0 | 35.8 | 36.7 | 37.6 | 38.7 | 39.9 | 41.2 | 42.6 | 44.2 | 45.9 |  | 0.1                         | 0.3    | 0.4    |
| 9 38.4                        | 32.3                                        | 33.0 | 33.8 | 34.6 | 35.5 | 36.5 | 37.6 | 38.8 | 40.1 | 41.6 | 43.3 |  | 0.1                         | 0.2    | 0.4    |
| 48.4                          | 30.3                                        | 30.9 | 31.6 | 32.4 | 33.2 | 34.1 | 35.2 | 36.3 | 37.6 | 39.0 | 40.5 |  | 0.1                         | 0.2    | 0.3    |
| 58.4                          | 28.2                                        | 28.8 | 29.4 | 30.1 | 30.9 | 31.8 | 32.7 | 33.8 | 34.9 | 36.2 | 37.7 |  | 0.1                         | 0.2    | 0.3    |
| 10 08.3                       | 26.0                                        | 26.6 | 27.2 | 27.8 | 28.5 | 29.3 | 30.2 | 31.2 | 32.3 | 33.5 | 34.8 |  | 0.1                         | 0.2    | 0.3    |
| 18.3                          | 23.8                                        | 24.3 | 24.8 | 25.4 | 26.1 | 26.8 | 27.6 | 28.5 | 29.5 | 30.6 | 31.8 |  | 0.1                         | 0.2    | 0.3    |
| 28.3                          | 21.6                                        | 22.0 | 22.5 | 23.0 | 23.6 | 24.3 | 25.0 | 25.8 | 26.7 | 27.7 | 28.8 |  | 0.1                         | 0.2    | 0.2    |
| 10 38.3                       | 19.3                                        | 19.7 | 20.1 | 20.6 | 21.1 | 21.7 | 22.4 | 23.1 | 23.9 | 24.8 | 25.7 |  | 0.1                         | 0.1    | 0.2    |
| 48.2                          | 16.9                                        | 17.3 | 17.7 | 18.1 | 18.6 | 19.1 | 19.7 | 20.3 | 21.0 | 21.8 | 22.6 |  | 0.1                         | 0.1    | 0.2    |
| 58.2                          | 14.6                                        | 14.9 | 15.2 | 15.6 | 16.0 | 16.4 | 16.9 | 17.5 | 18.1 | 18.7 | 19.5 |  | 0.1                         | 0.1    | 0.2    |
| 11 08.2                       | 12.2                                        | 12.4 | 12.7 | 13.0 | 13.4 | 13.7 | 14.1 | 14.6 | 15.1 | 15.7 | 16.3 |  | 0.0                         | 0.1    | 0.1    |
| 18.1                          | 9.8                                         | 10.0 | 10.2 | 10.4 | 10.7 | 11.0 | 11.3 | 11.7 | 12.1 | 12.6 | 13.1 |  | 0.0                         | 0.1    | 0.1    |
| 28.1                          | 7.4                                         | 7.5  | 7.7  | 7.9  | 8.1  | 8.3  | 8.5  | 8.8  | 9.1  | 9.4  | 9.8  |  | 0.0                         | 0.1    | 0.1    |
| 11 38.1                       | 4.9                                         | 5.0  | 5.1  | 5.2  | 5.4  | 5.5  | 5.7  | 5.9  | 6.1  | 6.3  | 6.6  |  | 0.0                         | 0.0    | 0.1    |
| 48.1                          | 2.5                                         | 2.5  | 2.6  | 2.6  | 2.7  | 2.8  | 2.8  | 2.9  | 3.0  | 3.2  | 3.3  |  | 0.0                         | 0.0    | 0.0    |
| 58.0                          | 0.0                                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |  | 0.0                         | 0.0    | 0.0    |

Tan A = 
$$\frac{\sin t}{\cos \phi \tan \delta - \sin \phi \cos t}$$

The product,  $\sin \phi \cos t$ , is subtracted for hour angles  
0° to 90° and added for hour angles from 90° to 180°.

| Mean<br>Time<br>Hour<br>Angle |      | AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1981 |      |      |      |      |      |      |      |      |      |      |     | CORR. TO AZIMUTH            |        |        |
|-------------------------------|------|---------------------------------------------|------|------|------|------|------|------|------|------|------|------|-----|-----------------------------|--------|--------|
|                               |      | Mean Declination + 89° 10' 50"              |      |      |      |      |      |      |      |      |      |      |     | Add for<br>Decl. + 89°      |        |        |
|                               |      |                                             |      |      |      |      |      |      |      |      |      |      |     | 10'40"                      | 10'30" | 10'20" |
|                               |      | Latitude                                    |      |      |      |      |      |      |      |      |      |      |     | Subtract for<br>Decl. + 89° |        |        |
|                               |      | 50°                                         | 52°  | 54°  | 56°  | 58°  | 60°  | 61°  | 62°  | 63°  | 64°  | 65°  | Az. | 11'00"                      | 11'10" | 11'20" |
| h                             | m    | /                                           | /    | /    | /    | /    | /    | /    | /    | /    | /    | /    | °   | /                           | /      | /      |
| 0                             | 00.0 | 0.0                                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0   | 0.0                         | 0.0    | 0.0    |
| 0                             | 10.0 | 3.4                                         | 3.5  | 3.7  | 3.9  | 4.1  | 4.4  | 4.5  | 4.7  | 4.9  | 5.0  | 5.2  |     | 0.0                         | 0.0    | 0.0    |
|                               | 19.9 | 6.8                                         | 7.1  | 7.4  | 7.8  | 8.3  | 8.8  | 9.1  | 9.4  | 9.7  | 10.1 | 10.5 |     | 0.0                         | 0.1    | 0.1    |
|                               | 29.9 | 10.2                                        | 10.6 | 11.1 | 11.7 | 12.4 | 13.2 | 13.6 | 14.0 | 14.5 | 15.1 | 15.7 |     | 0.0                         | 0.1    | 0.1    |
| 0                             | 39.9 | 13.5                                        | 14.1 | 14.8 | 15.6 | 16.5 | 17.5 | 18.1 | 18.7 | 19.3 | 20.1 | 20.8 |     | 0.1                         | 0.1    | 0.2    |
|                               | 49.9 | 16.8                                        | 17.6 | 18.5 | 19.4 | 20.5 | 21.8 | 22.5 | 23.3 | 24.1 | 25.0 | 26.0 |     | 0.1                         | 0.1    | 0.2    |
|                               | 59.8 | 20.1                                        | 21.0 | 22.1 | 23.2 | 24.6 | 26.1 | 26.9 | 27.8 | 28.8 | 29.9 | 31.0 |     | 0.1                         | 0.2    | 0.2    |
| 1                             | 09.8 | 23.4                                        | 24.4 | 25.6 | 27.0 | 28.5 | 30.3 | 31.3 | 32.3 | 33.5 | 34.7 | 36.0 |     | 0.1                         | 0.2    | 0.3    |
|                               | 19.8 | 26.6                                        | 27.8 | 29.1 | 30.7 | 32.4 | 34.4 | 35.5 | 36.7 | 38.0 | 39.4 | 41.0 |     | 0.1                         | 0.2    | 0.3    |
|                               | 29.8 | 29.7                                        | 31.1 | 32.6 | 34.3 | 36.3 | 38.5 | 39.8 | 41.1 | 42.5 | 44.1 | 45.8 |     | 0.1                         | 0.2    | 0.4    |
| 1                             | 39.7 | 32.8                                        | 34.3 | 36.0 | 37.9 | 40.0 | 42.5 | 43.9 | 45.4 | 47.0 | 48.7 | 50.6 |     | 0.1                         | 0.3    | 0.4    |
|                               | 49.7 | 35.9                                        | 37.5 | 39.3 | 41.4 | 43.7 | 46.4 | 47.9 | 49.5 | 51.3 | 53.2 | 55.2 |     | 0.1                         | 0.3    | 0.4    |
|                               | 59.7 | 38.8                                        | 40.6 | 42.5 | 44.8 | 47.3 | 50.2 | 51.9 | 53.6 | 55.5 | 57.5 | 59.8 | 0   | 0.2                         | 0.3    | 0.5    |
| 2                             | 09.6 | 41.7                                        | 43.6 | 45.7 | 48.1 | 50.8 | 54.0 | 55.7 | 57.6 | 59.6 | 1.8  | 4.2  | 1   | 0.2                         | 0.3    | 0.5    |
|                               | 19.6 | 44.5                                        | 46.5 | 48.8 | 51.3 | 54.2 | 57.6 | 59.4 | 1.4  | 3.6  | 5.9  | 8.4  |     | 0.2                         | 0.4    | 0.6    |
|                               | 29.6 | 47.2                                        | 49.3 | 51.7 | 54.4 | 57.5 | 1.1  | 3.0  | 5.1  | 7.4  | 9.9  | 12.6 |     | 0.2                         | 0.4    | 0.6    |
| 2                             | 39.6 | 49.8                                        | 52.1 | 54.6 | 57.4 | 0.7  | 4.4  | 6.5  | 8.7  | 11.1 | 13.7 | 16.6 |     | 0.2                         | 0.4    | 0.6    |
|                               | 49.5 | 52.3                                        | 54.7 | 57.3 | 0.3  | 3.8  | 7.7  | 9.8  | 12.2 | 14.7 | 17.4 | 20.4 |     | 0.2                         | 0.4    | 0.6    |
|                               | 59.5 | 54.7                                        | 57.2 | 60.0 | 3.1  | 6.7  | 10.8 | 13.0 | 15.5 | 18.1 | 21.0 | 24.1 |     | 0.2                         | 0.5    | 0.7    |
| 3                             | 09.5 | 57.0                                        | 59.6 | 2.5  | 5.8  | 9.5  | 13.7 | 16.1 | 18.6 | 21.4 | 24.4 | 27.6 |     | 0.2                         | 0.5    | 0.7    |
|                               | 19.5 | 59.2                                        | 1.9  | 4.9  | 8.3  | 12.1 | 16.5 | 19.0 | 21.6 | 24.5 | 27.6 | 30.9 |     | 0.2                         | 0.5    | 0.7    |
|                               | 29.4 | 1.3                                         | 4.1  | 7.2  | 10.7 | 14.6 | 19.2 | 21.7 | 24.5 | 27.4 | 30.6 | 34.0 |     | 0.3                         | 0.5    | 0.8    |
| 3                             | 39.4 | 3.3                                         | 6.1  | 9.3  | 12.9 | 17.0 | 21.7 | 24.3 | 27.1 | 30.2 | 33.4 | 37.0 |     | 0.3                         | 0.5    | 0.8    |
|                               | 49.4 | 5.1                                         | 8.0  | 11.3 | 15.0 | 19.2 | 24.0 | 26.7 | 29.6 | 32.7 | 36.1 | 39.7 |     | 0.3                         | 0.5    | 0.8    |
|                               | 59.3 | 6.8                                         | 9.8  | 13.2 | 17.0 | 21.3 | 26.2 | 29.0 | 31.9 | 35.1 | 38.6 | 42.3 |     | 0.3                         | 0.6    | 0.8    |
| 4                             | 09.3 | 8.4                                         | 11.4 | 14.9 | 18.8 | 23.2 | 28.2 | 31.0 | 34.0 | 37.3 | 40.8 | 44.7 |     | 0.3                         | 0.6    | 0.8    |
|                               | 19.3 | 9.8                                         | 12.9 | 16.4 | 20.4 | 24.9 | 30.0 | 32.9 | 36.0 | 39.3 | 42.9 | 46.8 |     | 0.3                         | 0.6    | 0.9    |
|                               | 29.3 | 11.1                                        | 14.3 | 17.9 | 21.9 | 26.5 | 31.7 | 34.6 | 37.7 | 41.1 | 44.8 | 48.7 |     | 0.3                         | 0.6    | 0.9    |
| 4                             | 39.2 | 12.3                                        | 15.5 | 19.1 | 23.2 | 27.9 | 33.2 | 36.1 | 39.3 | 42.7 | 46.4 | 50.5 |     | 0.3                         | 0.6    | 0.9    |
|                               | 49.2 | 13.3                                        | 16.6 | 20.2 | 24.4 | 29.1 | 34.5 | 37.5 | 40.7 | 44.1 | 47.9 | 52.0 |     | 0.3                         | 0.6    | 0.9    |
|                               | 59.2 | 14.2                                        | 17.5 | 21.2 | 25.4 | 30.1 | 35.6 | 38.6 | 41.8 | 45.3 | 49.1 | 53.2 |     | 0.3                         | 0.6    | 0.9    |
| 5                             | 09.2 | 14.9                                        | 18.3 | 22.0 | 26.2 | 31.0 | 36.5 | 39.5 | 42.8 | 46.4 | 50.2 | 54.3 |     | 0.3                         | 0.6    | 0.9    |
|                               | 19.1 | 15.5                                        | 18.9 | 22.6 | 26.9 | 31.7 | 37.2 | 40.3 | 43.6 | 47.1 | 51.0 | 55.1 |     | 0.3                         | 0.6    | 0.9    |
|                               | 29.1 | 16.0                                        | 19.4 | 23.1 | 27.4 | 32.2 | 37.8 | 40.9 | 44.2 | 47.7 | 51.6 | 55.8 |     | 0.3                         | 0.6    | 0.9    |
| 5                             | 39.1 | 16.3                                        | 19.7 | 23.5 | 27.7 | 32.6 | 38.2 | 41.2 | 44.5 | 48.1 | 52.0 | 56.2 |     | 0.3                         | 0.6    | 0.9    |
|                               | 49.0 | 16.5                                        | 19.8 | 23.6 | 27.9 | 32.8 | 38.3 | 41.4 | 44.7 | 48.3 | 52.2 | 56.3 |     | 0.3                         | 0.6    | 0.9    |
|                               | 52.0 | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 56.4 |     | 0.4                         | 0.8    | 1.2    |
| 5                             | 52.3 | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 52.2 | ...  |     | 0.4                         | 0.8    | 1.1    |
|                               | 52.6 | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 48.3 | ...  | ...  |     | 0.4                         | 0.7    | 1.1    |
|                               | 52.9 | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | 44.7 | ...  | ...  | ...  |     | 0.4                         | 0.7    | 1.1    |
| 5                             | 53.1 | ...                                         | ...  | ...  | ...  | ...  | ...  | 41.4 | ...  | ...  | ...  | ...  |     | 0.3                         | 0.7    | 1.0    |
|                               | 53.4 | ...                                         | ...  | ...  | ...  | ...  | 38.3 | ...  | ...  | ...  | ...  | ...  |     | 0.3                         | 0.7    | 1.0    |
|                               | 53.8 | ...                                         | ...  | ...  | ...  | 32.8 | ...  | ...  | ...  | ...  | ...  | ...  |     | 0.3                         | 0.6    | 0.9    |
| 5                             | 54.2 | ...                                         | ...  | ...  | 27.9 | ...  | ...  | ...  | ...  | ...  | ...  | ...  |     | 0.3                         | 0.6    | 0.9    |
|                               | 54.5 | ...                                         | ...  | 23.7 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |     | 0.3                         | 0.6    | 0.9    |
|                               | 54.8 | ...                                         | 19.9 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  |     | 0.3                         | 0.5    | 0.8    |
| 5                             | 55.1 | 16.5                                        | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 1   | 0.3                         | 0.5    | 0.8    |

See footnote pages 18 and 19 for equation to be employed when values in seconds are required.

| Mean<br>Time<br>Hour<br>Angle | AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1981 |      |      |      |      |      |      |      |      |      |      |     | CORR. TO AZIMUTH            |        |        |
|-------------------------------|---------------------------------------------|------|------|------|------|------|------|------|------|------|------|-----|-----------------------------|--------|--------|
|                               | Mean Declination + 89° 10' 50"              |      |      |      |      |      |      |      |      |      |      |     | Add for<br>Decl. + 89°      |        |        |
|                               |                                             |      |      |      |      |      |      |      |      |      |      |     | 10'40"                      | 10'30" | 10'20" |
|                               | Latitude                                    |      |      |      |      |      |      |      |      |      |      |     | Subtract for<br>Decl. + 89° |        |        |
|                               | 50°                                         | 52°  | 54°  | 56°  | 58°  | 60°  | 61°  | 62°  | 63°  | 64°  | 65°  | Az. | 11'00"                      | 11'10" | 11'20" |
| h m                           | /                                           | /    | /    | /    | /    | /    | /    | /    | /    | /    | /    | °   | /                           | /      | /      |
| 5 52.0                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 56.4 | 1   | 0.4                         | 0.8    | 1.2    |
| 52.3                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 52.2 | ...  | ... | 0.4                         | 0.8    | 1.1    |
| 52.6                          | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | ...  | 48.3 | ...  | ...  | ... | 0.4                         | 0.7    | 1.1    |
| 5 52.9                        | ...                                         | ...  | ...  | ...  | ...  | ...  | ...  | 44.7 | ...  | ...  | ...  | ... | 0.4                         | 0.7    | 1.1    |
| 53.1                          | ...                                         | ...  | ...  | ...  | ...  | ...  | 41.4 | ...  | ...  | ...  | ...  | ... | 0.3                         | 0.7    | 1.0    |
| 53.4                          | ...                                         | ...  | ...  | ...  | ...  | 38.3 | ...  | ...  | ...  | ...  | ...  | ... | 0.3                         | 0.7    | 1.0    |
| 5 53.8                        | ...                                         | ...  | ...  | ...  | 32.8 | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.3                         | 0.6    | 0.9    |
| 54.2                          | ...                                         | ...  | ...  | 27.9 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.3                         | 0.6    | 0.9    |
| 54.5                          | ...                                         | ...  | 23.7 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.3                         | 0.6    | 0.9    |
| 5 54.8                        | ...                                         | 19.9 | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.3                         | 0.5    | 0.8    |
| 55.1                          | 16.5                                        | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ...  | ... | 0.3                         | 0.5    | 0.8    |
| 59.0                          | 16.5                                        | 19.9 | 23.6 | 27.9 | 32.8 | 38.3 | 41.4 | 44.7 | 48.3 | 52.1 | 56.3 | ... | 0.3                         | 0.6    | 0.9    |
| 6 09.0                        | 16.4                                        | 19.7 | 23.5 | 27.7 | 32.6 | 38.1 | 41.2 | 44.5 | 48.0 | 51.9 | 56.0 | ... | 0.3                         | 0.6    | 0.9    |
| 19.0                          | 16.1                                        | 19.4 | 23.2 | 27.4 | 32.2 | 37.7 | 40.8 | 44.1 | 47.6 | 51.4 | 55.6 | ... | 0.3                         | 0.6    | 0.9    |
| 28.9                          | 15.7                                        | 19.0 | 22.7 | 26.9 | 31.7 | 37.2 | 40.2 | 43.4 | 47.0 | 50.7 | 54.8 | ... | 0.3                         | 0.6    | 0.9    |
| 6 38.9                        | 15.1                                        | 18.4 | 22.1 | 26.3 | 31.0 | 36.4 | 39.4 | 42.6 | 46.1 | 49.9 | 53.9 | ... | 0.3                         | 0.6    | 0.9    |
| 48.9                          | 14.4                                        | 17.7 | 21.3 | 25.4 | 30.1 | 35.5 | 38.4 | 41.6 | 45.1 | 48.8 | 52.8 | ... | 0.3                         | 0.6    | 0.9    |
| 58.9                          | 13.6                                        | 16.8 | 20.4 | 24.5 | 29.1 | 34.4 | 37.3 | 40.4 | 43.8 | 47.5 | 51.5 | ... | 0.3                         | 0.6    | 0.9    |
| 7 08.8                        | 12.6                                        | 15.7 | 19.3 | 23.3 | 27.9 | 33.1 | 36.0 | 39.1 | 42.4 | 46.0 | 49.9 | ... | 0.3                         | 0.6    | 0.9    |
| 18.8                          | 11.5                                        | 14.6 | 18.1 | 22.0 | 26.5 | 31.6 | 34.4 | 37.5 | 40.8 | 44.3 | 48.2 | ... | 0.3                         | 0.6    | 0.9    |
| 28.8                          | 10.2                                        | 13.3 | 16.7 | 20.6 | 25.0 | 30.0 | 32.8 | 35.8 | 39.0 | 42.4 | 46.2 | ... | 0.3                         | 0.6    | 0.9    |
| 7 38.7                        | 8.8                                         | 11.8 | 15.2 | 19.0 | 23.3 | 28.2 | 30.9 | 33.8 | 37.0 | 40.4 | 44.1 | ... | 0.3                         | 0.6    | 0.8    |
| 48.7                          | 7.3                                         | 10.2 | 13.5 | 17.2 | 21.4 | 26.2 | 28.9 | 31.7 | 34.8 | 38.1 | 41.7 | ... | 0.3                         | 0.6    | 0.8    |
| 58.7                          | 5.7                                         | 8.5  | 11.7 | 15.3 | 19.4 | 24.1 | 26.7 | 29.5 | 32.5 | 35.7 | 39.2 | ... | 0.3                         | 0.5    | 0.8    |
| 8 08.7                        | 3.9                                         | 6.7  | 9.8  | 13.3 | 17.3 | 21.8 | 24.4 | 27.1 | 30.0 | 33.1 | 36.5 | ... | 0.3                         | 0.5    | 0.8    |
| 18.6                          | 2.0                                         | 4.7  | 7.8  | 11.2 | 15.0 | 19.4 | 21.9 | 24.5 | 27.3 | 30.3 | 33.6 | ... | 0.3                         | 0.5    | 0.8    |
| 28.6                          | 0.1                                         | 2.7  | 5.6  | 8.9  | 12.6 | 16.8 | 19.2 | 21.7 | 24.5 | 27.4 | 30.6 | ... | 0.2                         | 0.5    | 0.7    |
| 8 38.6                        | 58.0                                        | 0.5  | 3.3  | 6.4  | 10.0 | 14.1 | 16.4 | 18.9 | 21.5 | 24.3 | 27.4 | ... | 0.2                         | 0.5    | 0.7    |
| 48.6                          | 55.8                                        | 58.2 | 0.9  | 3.9  | 7.4  | 11.3 | 13.5 | 15.8 | 18.4 | 21.1 | 24.0 | ... | 0.2                         | 0.5    | 0.7    |
| 58.5                          | 53.4                                        | 55.7 | 58.3 | 1.3  | 4.6  | 8.3  | 10.4 | 12.7 | 15.1 | 17.7 | 20.5 | ... | 0.2                         | 0.4    | 0.7    |
| 9 08.5                        | 51.0                                        | 53.2 | 55.7 | 58.5 | 1.6  | 5.2  | 7.2  | 9.4  | 11.7 | 14.2 | 16.9 | ... | 0.2                         | 0.4    | 0.6    |
| 18.5                          | 48.5                                        | 50.6 | 53.0 | 55.6 | 58.6 | 2.0  | 3.9  | 6.0  | 8.1  | 10.5 | 13.1 | ... | 0.2                         | 0.4    | 0.6    |
| 28.4                          | 45.9                                        | 47.9 | 50.1 | 52.6 | 55.5 | 58.7 | 0.5  | 2.4  | 4.5  | 6.7  | 9.1  | ... | 0.2                         | 0.4    | 0.6    |
| 9 38.4                        | 43.3                                        | 45.1 | 47.2 | 49.6 | 52.2 | 55.3 | 57.0 | 58.8 | 0.7  | 2.8  | 5.1  | ... | 0.2                         | 0.4    | 0.5    |
| 48.4                          | 40.5                                        | 42.3 | 44.2 | 46.4 | 48.9 | 51.8 | 53.3 | 55.0 | 56.8 | 58.8 | 0.9  | 1   | 0.2                         | 0.3    | 0.5    |
| 58.4                          | 37.7                                        | 39.3 | 41.1 | 43.2 | 45.5 | 48.1 | 49.6 | 51.2 | 52.9 | 54.7 | 56.7 | 0   | 0.2                         | 0.3    | 0.5    |
| 10 08.3                       | 34.8                                        | 36.3 | 38.0 | 39.9 | 42.0 | 44.4 | 45.8 | 47.2 | 48.8 | 50.5 | 52.3 | ... | 0.1                         | 0.3    | 0.4    |
| 18.3                          | 31.8                                        | 33.2 | 34.7 | 36.5 | 38.4 | 40.6 | 41.9 | 43.2 | 44.6 | 46.2 | 47.8 | ... | 0.1                         | 0.3    | 0.4    |
| 28.3                          | 28.8                                        | 30.1 | 31.4 | 33.0 | 34.8 | 36.8 | 37.9 | 39.1 | 40.4 | 41.8 | 43.3 | ... | 0.1                         | 0.2    | 0.4    |
| 10 38.3                       | 25.7                                        | 26.9 | 28.1 | 29.5 | 31.1 | 32.9 | 33.9 | 34.9 | 36.1 | 37.3 | 38.7 | ... | 0.1                         | 0.2    | 0.3    |
| 48.2                          | 22.6                                        | 23.6 | 24.7 | 25.9 | 27.3 | 28.9 | 29.8 | 30.7 | 31.7 | 32.8 | 34.0 | ... | 0.1                         | 0.2    | 0.3    |
| 58.2                          | 19.5                                        | 20.3 | 21.2 | 22.3 | 23.5 | 24.9 | 25.6 | 26.4 | 27.3 | 28.2 | 29.2 | ... | 0.1                         | 0.2    | 0.2    |
| 11 08.2                       | 16.3                                        | 17.0 | 17.8 | 18.6 | 19.6 | 20.8 | 21.4 | 22.1 | 22.8 | 23.6 | 24.4 | ... | 0.1                         | 0.1    | 0.2    |
| 18.1                          | 13.1                                        | 13.6 | 14.2 | 15.0 | 15.8 | 16.7 | 17.2 | 17.7 | 18.3 | 18.9 | 19.6 | ... | 0.1                         | 0.1    | 0.2    |
| 28.1                          | 9.8                                         | 10.2 | 10.7 | 11.2 | 11.8 | 12.5 | 12.9 | 13.3 | 13.8 | 14.2 | 14.7 | ... | 0.0                         | 0.1    | 0.1    |
| 11 38.1                       | 6.6                                         | 6.8  | 7.2  | 7.5  | 7.9  | 8.4  | 8.6  | 8.9  | 9.2  | 9.5  | 9.8  | ... | 0.0                         | 0.1    | 0.1    |
| 48.1                          | 3.3                                         | 3.4  | 3.6  | 3.8  | 4.0  | 4.2  | 4.3  | 4.4  | 4.6  | 4.8  | 4.9  | ... | 0.0                         | 0.0    | 0.0    |
| 58.0                          | 0.0                                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0   | 0.0                         | 0.0    | 0.0    |

See footnote pages 18 and 19 for equation to be employed when values in seconds are required.

| Lat.  | Correction<br>to the<br>Time of<br>Elongation | AZIMUTH OF POLARIS AT ELONGATION, 1981 |         |         |         |         |         |         |       |
|-------|-----------------------------------------------|----------------------------------------|---------|---------|---------|---------|---------|---------|-------|
|       |                                               | Decl. +89°                             |         |         |         |         |         |         |       |
|       |                                               | 10' 20"                                | 10' 30" | 10' 40" | 10' 50" | 11' 00" | 11' 10" | 11' 20" |       |
| ° /   | W.E. m E.E.                                   | ° / "                                  | ° / "   | ° / "   | ° / "   | ° / "   | ° / "   | ° / "   | ° / " |
| 10 00 | +2.2-                                         | 0 50 26                                | 0 50 16 | 0 50 06 | 0 49 56 | 0 49 45 | 0 49 35 | 0 49 25 |       |
| 12 00 | 2.1                                           | 0 50 47                                | 0 50 36 | 0 50 26 | 0 50 16 | 0 50 06 | 0 49 55 | 0 49 45 |       |
| 14 00 | 1.9                                           | 0 51 11                                | 0 51 01 | 0 50 51 | 0 50 40 | 0 50 30 | 0 50 20 | 0 50 09 |       |
| 16 00 | 1.8                                           | 0 51 40                                | 0 51 30 | 0 51 19 | 0 51 09 | 0 50 58 | 0 50 48 | 0 50 38 |       |
| 18 00 | 1.7                                           | 0 52 13                                | 0 52 03 | 0 51 52 | 0 51 42 | 0 51 31 | 0 51 21 | 0 51 10 |       |
| 20 00 | 1.6                                           | 0 52 51                                | 0 52 41 | 0 52 30 | 0 52 19 | 0 52 09 | 0 51 58 | 0 51 47 |       |
| 21 00 | 1.5                                           | 0 53 12                                | 0 53 01 | 0 52 51 | 0 52 40 | 0 52 29 | 0 52 18 | 0 52 08 |       |
| 22 00 | 1.4                                           | 0 53 34                                | 0 53 23 | 0 53 12 | 0 53 02 | 0 52 51 | 0 52 40 | 0 52 29 |       |
| 23 00 | 1.4                                           | 0 53 57                                | 0 53 47 | 0 53 36 | 0 53 25 | 0 53 14 | 0 53 03 | 0 52 52 |       |
| 24 00 | 1.3                                           | 0 54 22                                | 0 54 11 | 0 54 00 | 0 53 49 | 0 53 38 | 0 53 27 | 0 53 16 |       |
| 25 00 | 1.2                                           | 0 54 48                                | 0 54 37 | 0 54 26 | 0 54 15 | 0 54 04 | 0 53 53 | 0 53 42 |       |
| 26 00 | 1.2                                           | 0 55 16                                | 0 55 04 | 0 54 53 | 0 54 42 | 0 54 31 | 0 54 20 | 0 54 09 |       |
| 27 00 | 1.1                                           | 0 55 45                                | 0 55 33 | 0 55 22 | 0 55 11 | 0 55 00 | 0 54 48 | 0 54 37 |       |
| 28 00 | 1.0                                           | 0 56 15                                | 0 56 04 | 0 55 52 | 0 55 41 | 0 55 30 | 0 55 18 | 0 55 07 |       |
| 29 00 | 0.9                                           | 0 56 47                                | 0 56 36 | 0 56 24 | 0 56 13 | 0 56 01 | 0 55 50 | 0 55 39 |       |
| 30 00 | 0.9                                           | 0 57 21                                | 0 57 10 | 0 56 58 | 0 56 46 | 0 56 35 | 0 56 23 | 0 56 12 |       |
| 31 00 | 0.8                                           | 0 57 57                                | 0 57 45 | 0 57 33 | 0 57 22 | 0 57 10 | 0 56 58 | 0 56 47 |       |
| 32 00 | 0.7                                           | 0 58 34                                | 0 58 22 | 0 58 10 | 0 57 59 | 0 57 47 | 0 57 35 | 0 57 23 |       |
| 33 00 | 0.6                                           | 0 59 13                                | 0 59 01 | 0 58 49 | 0 58 38 | 0 58 26 | 0 58 14 | 0 58 02 |       |
| 34 00 | 0.5                                           | 0 59 55                                | 0 59 43 | 0 59 30 | 0 59 18 | 0 59 06 | 0 58 54 | 0 58 42 |       |
| 35 00 | 0.5                                           | 1 00 38                                | 1 00 26 | 1 00 14 | 1 00 01 | 0 59 49 | 0 59 37 | 0 59 25 |       |
| 36 00 | 0.4                                           | 1 01 24                                | 1 01 11 | 1 00 59 | 1 00 46 | 1 00 34 | 1 00 22 | 1 00 09 |       |
| 37 00 | 0.3                                           | 1 02 11                                | 1 01 59 | 1 01 46 | 1 01 34 | 1 01 21 | 1 01 09 | 1 00 56 |       |
| 38 00 | 0.2                                           | 1 03 02                                | 1 02 49 | 1 02 36 | 1 02 24 | 1 02 11 | 1 01 58 | 1 01 46 |       |
| 39 00 | +0.1-                                         | 1 03 55                                | 1 03 42 | 1 03 29 | 1 03 16 | 1 03 03 | 1 02 50 | 1 02 37 |       |
| 40 00 | 0.0                                           | 1 04 50                                | 1 04 37 | 1 04 24 | 1 04 11 | 1 03 58 | 1 03 45 | 1 03 32 |       |
| 41 00 | -0.1+                                         | 1 05 49                                | 1 05 35 | 1 05 22 | 1 05 09 | 1 04 56 | 1 04 42 | 1 04 29 |       |
| 42 00 | 0.2                                           | 1 06 50                                | 1 06 37 | 1 06 23 | 1 06 10 | 1 05 56 | 1 05 43 | 1 05 29 |       |
| 43 00 | 0.3                                           | 1 07 55                                | 1 07 41 | 1 07 27 | 1 07 14 | 1 07 00 | 1 06 46 | 1 06 33 |       |
| 44 00 | 0.4                                           | 1 09 03                                | 1 08 49 | 1 08 35 | 1 08 21 | 1 08 07 | 1 07 53 | 1 07 39 |       |
| 45 00 | 0.5                                           | 1 10 15                                | 1 10 00 | 1 09 46 | 1 09 32 | 1 09 18 | 1 09 04 | 1 08 50 |       |
| 46 00 | 0.6                                           | 1 11 30                                | 1 11 16 | 1 11 01 | 1 10 47 | 1 10 32 | 1 10 18 | 1 10 04 |       |
| 47 00 | 0.8                                           | 1 12 50                                | 1 12 35 | 1 12 20 | 1 12 06 | 1 11 51 | 1 11 36 | 1 11 22 |       |
| 48 00 | 0.9                                           | 1 14 14                                | 1 13 59 | 1 13 44 | 1 13 29 | 1 13 14 | 1 12 59 | 1 12 44 |       |
| 49 00 | 1.0                                           | 1 15 42                                | 1 15 27 | 1 15 12 | 1 14 57 | 1 14 42 | 1 14 26 | 1 14 11 |       |
| 50 00 | 1.2                                           | 1 17 16                                | 1 17 01 | 1 16 45 | 1 16 30 | 1 16 14 | 1 15 58 | 1 15 43 |       |
| 51 00 | 1.3                                           | 1 18 56                                | 1 18 40 | 1 18 24 | 1 18 08 | 1 17 52 | 1 17 36 | 1 17 20 |       |
| 52 00 | 1.4                                           | 1 20 41                                | 1 20 24 | 1 20 08 | 1 19 52 | 1 19 36 | 1 19 19 | 1 19 03 |       |
| 53 00 | 1.6                                           | 1 22 32                                | 1 22 15 | 1 21 59 | 1 21 42 | 1 21 26 | 1 21 09 | 1 20 52 |       |
| 54 00 | 1.8                                           | 1 24 30                                | 1 24 13 | 1 23 56 | 1 23 39 | 1 23 22 | 1 23 05 | 1 22 48 |       |
| 55 00 | 1.9                                           | 1 26 36                                | 1 26 18 | 1 26 01 | 1 25 44 | 1 25 26 | 1 25 09 | 1 24 51 |       |
| 55 30 | 2.0                                           | 1 27 42                                | 1 27 24 | 1 27 06 | 1 26 49 | 1 26 31 | 1 26 13 | 1 25 56 |       |
| 56 00 | 2.1                                           | 1 28 50                                | 1 28 32 | 1 28 14 | 1 27 56 | 1 27 38 | 1 27 20 | 1 27 02 |       |
| 56 30 | 2.2                                           | 1 30 00                                | 1 29 41 | 1 29 23 | 1 29 05 | 1 28 47 | 1 28 29 | 1 28 11 |       |
| 57 00 | 2.3                                           | 1 31 12                                | 1 30 54 | 1 30 35 | 1 30 17 | 1 29 59 | 1 29 40 | 1 29 22 |       |
| 57 30 | 2.4                                           | 1 32 27                                | 1 32 08 | 1 31 49 | 1 31 31 | 1 31 12 | 1 30 54 | 1 30 35 |       |
| 58 00 | 2.5                                           | 1 33 44                                | 1 33 25 | 1 33 06 | 1 32 47 | 1 32 28 | 1 32 10 | 1 31 51 |       |
| 58 30 | 2.6                                           | 1 35 04                                | 1 34 45 | 1 34 26 | 1 34 06 | 1 33 47 | 1 33 28 | 1 33 09 |       |
| 59 00 | 2.7                                           | 1 36 27                                | 1 36 07 | 1 35 48 | 1 35 28 | 1 35 09 | 1 34 49 | 1 34 30 |       |
| 59 30 | 2.8                                           | 1 37 52                                | 1 37 32 | 1 37 13 | 1 36 53 | 1 36 33 | 1 36 14 | 1 35 54 |       |
| 60 00 | 2.9                                           | 1 39 21                                | 1 39 01 | 1 38 41 | 1 38 21 | 1 38 01 | 1 37 41 | 1 37 21 |       |
| 60 30 | 3.1                                           | 1 40 52                                | 1 40 32 | 1 40 12 | 1 39 51 | 1 39 31 | 1 39 11 | 1 38 50 |       |
| 61 00 | 3.2                                           | 1 42 27                                | 1 42 07 | 1 41 46 | 1 41 26 | 1 41 05 | 1 40 44 | 1 40 24 |       |
| 61 30 | 3.3                                           | 1 44 06                                | 1 43 45 | 1 43 24 | 1 43 03 | 1 42 42 | 1 42 21 | 1 42 00 |       |
| 62 00 | 3.4                                           | 1 45 48                                | 1 45 27 | 1 45 06 | 1 44 44 | 1 44 23 | 1 44 02 | 1 43 40 |       |
| 62 30 | 3.6                                           | 1 47 35                                | 1 47 13 | 1 46 51 | 1 46 30 | 1 46 08 | 1 45 46 | 1 45 25 |       |
| 63 00 | 3.7                                           | 1 49 25                                | 1 49 03 | 1 48 41 | 1 48 19 | 1 47 57 | 1 47 35 | 1 47 13 |       |
| 63 30 | 3.8                                           | 1 51 20                                | 1 50 57 | 1 50 35 | 1 50 12 | 1 49 50 | 1 49 27 | 1 49 05 |       |
| 64 00 | 4.0                                           | 1 53 19                                | 1 52 56 | 1 52 33 | 1 52 10 | 1 51 48 | 1 51 25 | 1 51 02 |       |
| 64 30 | 4.1                                           | 1 55 23                                | 1 55 00 | 1 54 37 | 1 54 13 | 1 53 50 | 1 53 27 | 1 53 04 |       |
| 65 00 | 4.3                                           | 1 57 32                                | 1 57 09 | 1 56 45 | 1 56 21 | 1 55 58 | 1 55 34 | 1 55 10 |       |
| 65 30 | 4.5                                           | 1 59 47                                | 1 59 23 | 1 58 59 | 1 58 35 | 1 58 11 | 1 57 47 | 1 57 22 |       |
| 66 00 | 4.6                                           | 2 02 08                                | 2 01 43 | 2 01 19 | 2 00 54 | 2 00 29 | 2 00 05 | 1 59 40 |       |
| 66 30 | 4.8                                           | 2 04 35                                | 2 04 10 | 2 03 45 | 2 03 19 | 2 02 54 | 2 02 29 | 2 02 04 |       |
| 67 00 | 5.0                                           | 2 07 08                                | 2 06 43 | 2 06 17 | 2 05 51 | 2 05 26 | 2 05 00 | 2 04 35 |       |
| 67 30 | 5.2                                           | 2 09 49                                | 2 09 23 | 2 08 56 | 2 08 30 | 2 08 04 | 2 07 38 | 2 07 12 |       |
| 68 00 | 5.4                                           | 2 12 37                                | 2 12 10 | 2 11 43 | 2 11 17 | 2 10 50 | 2 10 23 | 2 09 56 |       |
| 68 30 | 5.6                                           | 2 15 33                                | 2 15 05 | 2 14 38 | 2 14 11 | 2 13 44 | 2 13 16 | 2 12 49 |       |
| 69 00 | 5.8                                           | 2 18 37                                | 2 18 10 | 2 17 42 | 2 17 14 | 2 16 46 | 2 16 18 | 2 15 50 |       |
| 69 30 | 6.0                                           | 2 21 51                                | 2 21 23 | 2 20 54 | 2 20 26 | 2 19 57 | 2 19 28 | 2 19 00 |       |
| 70 00 | -6.3+                                         | 2 25 15                                | 2 24 46 | 2 24 17 | 2 23 47 | 2 23 18 | 2 22 49 | 2 22 20 |       |

| TO FIND THE LATITUDE BY AN ALTITUDE OBSERVATION OF POLARIS AT<br>ANY HOUR ANGLE, 1981                                                    |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                           |         |         |         |  |                               |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|---------|--|-------------------------------|
| Mean<br>Time<br>Hour<br>Angle                                                                                                            | Primary Adjustment to Elevation of Pole                                                                                                                                                                                       |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                           |         |         |         |  | Mean<br>Time<br>Hour<br>Angle |
|                                                                                                                                          | Subtract<br>Polaris Above the Pole                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               | Add<br>Polaris Below the Pole                                                                                                                                                                                                 |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                           |         |         |         |  |                               |
|                                                                                                                                          | Decl. +89°                                                                                                                                                                                                                    |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               | Decl. +89°                                                                                                                                                                                                                    |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                           |         |         |         |  |                               |
|                                                                                                                                          | 10' 20"                                                                                                                                                                                                                       | 10' 40"                                                                                                                                                                                                                       | 11' 00"                                                                                                                                                                                                                       | 11' 20"                                                                                                                                                                                                                       | 10' 20"                                                                                                                                                                                                                       | 10' 40"                                                                                                                                                                                                                       | 11' 00"                                                                                                                                                                                                                       | 11' 20"                                                                                                                                                                                                                       | 10' 20"                                                                                                                                   | 10' 40" | 11' 00" | 11' 20" |  |                               |
| <div><div>h m</div><div>0 00.0</div></div>                                                                                               | <div><div>° ' "</div><div>0 49 40</div></div>                                                                                                                                                                                 | <div><div>° ' "</div><div>0 49 20</div></div>                                                                                                                                                                                 | <div><div>° ' "</div><div>0 49 00</div></div>                                                                                                                                                                                 | <div><div>° ' "</div><div>0 48 40</div></div>                                                                                                                                                                                 | <div><div>° ' "</div><div>0 00 00</div></div> <div><div>° ' "</div><div>0 00 22</div></div>                                                                                                                                   | <div><div>° ' "</div><div>0 00 00</div></div> <div><div>° ' "</div><div>0 00 21</div></div>                                                                                                                                   | <div><div>° ' "</div><div>0 00 00</div></div> <div><div>° ' "</div><div>0 00 21</div></div>                                                                                                                                   | <div><div>° ' "</div><div>0 00 00</div></div> <div><div>° ' "</div><div>0 00 21</div></div>                                                                                                                                   | <div><div>h m</div><div>5 57.4</div></div> <div><div>h m</div><div>5 59.0</div></div>                                                     |         |         |         |  |                               |
| <div><div>0 12.0</div></div> <div><div>23.9</div></div> <div><div>35.9</div></div> <div><div>47.9</div></div> <div><div>59.8</div></div> | <div><div>° ' "</div><div>0 49 36</div></div> <div><div>° ' "</div><div>49 23</div></div> <div><div>° ' "</div><div>49 03</div></div> <div><div>° ' "</div><div>48 34</div></div> <div><div>° ' "</div><div>47 57</div></div> | <div><div>° ' "</div><div>0 49 16</div></div> <div><div>° ' "</div><div>49 04</div></div> <div><div>° ' "</div><div>48 43</div></div> <div><div>° ' "</div><div>48 14</div></div> <div><div>° ' "</div><div>47 38</div></div> | <div><div>° ' "</div><div>0 48 56</div></div> <div><div>° ' "</div><div>48 44</div></div> <div><div>° ' "</div><div>48 23</div></div> <div><div>° ' "</div><div>47 55</div></div> <div><div>° ' "</div><div>47 18</div></div> | <div><div>° ' "</div><div>0 48 36</div></div> <div><div>° ' "</div><div>48 24</div></div> <div><div>° ' "</div><div>48 04</div></div> <div><div>° ' "</div><div>47 35</div></div> <div><div>° ' "</div><div>46 59</div></div> | <div><div>° ' "</div><div>0 01 40</div></div> <div><div>° ' "</div><div>02 57</div></div> <div><div>° ' "</div><div>04 15</div></div> <div><div>° ' "</div><div>05 33</div></div> <div><div>° ' "</div><div>06 50</div></div> | <div><div>° ' "</div><div>0 01 39</div></div> <div><div>° ' "</div><div>02 56</div></div> <div><div>° ' "</div><div>04 13</div></div> <div><div>° ' "</div><div>05 30</div></div> <div><div>° ' "</div><div>06 47</div></div> | <div><div>° ' "</div><div>0 01 38</div></div> <div><div>° ' "</div><div>02 55</div></div> <div><div>° ' "</div><div>04 12</div></div> <div><div>° ' "</div><div>05 28</div></div> <div><div>° ' "</div><div>06 44</div></div> | <div><div>° ' "</div><div>0 01 37</div></div> <div><div>° ' "</div><div>02 53</div></div> <div><div>° ' "</div><div>04 10</div></div> <div><div>° ' "</div><div>05 26</div></div> <div><div>° ' "</div><div>06 41</div></div> | <div><div>6 05.0</div></div> <div><div>11.0</div></div> <div><div>17.0</div></div> <div><div>23.0</div></div> <div><div>28.9</div></div>  |         |         |         |  |                               |
| <div><div>1 11.8</div></div> <div><div>23.8</div></div> <div><div>35.7</div></div> <div><div>47.7</div></div> <div><div>59.7</div></div> | <div><div>° ' "</div><div>0 47 12</div></div> <div><div>° ' "</div><div>46 19</div></div> <div><div>° ' "</div><div>45 19</div></div> <div><div>° ' "</div><div>44 11</div></div> <div><div>° ' "</div><div>42 55</div></div> | <div><div>° ' "</div><div>0 46 53</div></div> <div><div>° ' "</div><div>46 01</div></div> <div><div>° ' "</div><div>45 01</div></div> <div><div>° ' "</div><div>43 53</div></div> <div><div>° ' "</div><div>42 38</div></div> | <div><div>° ' "</div><div>0 46 34</div></div> <div><div>° ' "</div><div>45 42</div></div> <div><div>° ' "</div><div>44 42</div></div> <div><div>° ' "</div><div>43 35</div></div> <div><div>° ' "</div><div>42 21</div></div> | <div><div>° ' "</div><div>0 46 15</div></div> <div><div>° ' "</div><div>45 23</div></div> <div><div>° ' "</div><div>44 24</div></div> <div><div>° ' "</div><div>43 18</div></div> <div><div>° ' "</div><div>42 04</div></div> | <div><div>° ' "</div><div>0 08 07</div></div> <div><div>° ' "</div><div>09 24</div></div> <div><div>° ' "</div><div>10 40</div></div> <div><div>° ' "</div><div>11 56</div></div> <div><div>° ' "</div><div>13 11</div></div> | <div><div>° ' "</div><div>0 08 04</div></div> <div><div>° ' "</div><div>09 20</div></div> <div><div>° ' "</div><div>10 36</div></div> <div><div>° ' "</div><div>11 51</div></div> <div><div>° ' "</div><div>13 06</div></div> | <div><div>° ' "</div><div>0 08 00</div></div> <div><div>° ' "</div><div>09 16</div></div> <div><div>° ' "</div><div>10 31</div></div> <div><div>° ' "</div><div>11 46</div></div> <div><div>° ' "</div><div>13 01</div></div> | <div><div>° ' "</div><div>0 07 57</div></div> <div><div>° ' "</div><div>09 12</div></div> <div><div>° ' "</div><div>10 27</div></div> <div><div>° ' "</div><div>11 41</div></div> <div><div>° ' "</div><div>12 55</div></div> | <div><div>6 34.9</div></div> <div><div>40.9</div></div> <div><div>46.9</div></div> <div><div>52.9</div></div> <div><div>58.9</div></div>  |         |         |         |  |                               |
| <div><div>2 11.6</div></div> <div><div>23.6</div></div> <div><div>35.6</div></div> <div><div>47.5</div></div> <div><div>59.5</div></div> | <div><div>° ' "</div><div>0 41 33</div></div> <div><div>° ' "</div><div>40 03</div></div> <div><div>° ' "</div><div>38 27</div></div> <div><div>° ' "</div><div>36 45</div></div> <div><div>° ' "</div><div>34 56</div></div> | <div><div>° ' "</div><div>0 41 16</div></div> <div><div>° ' "</div><div>39 47</div></div> <div><div>° ' "</div><div>38 12</div></div> <div><div>° ' "</div><div>36 30</div></div> <div><div>° ' "</div><div>34 42</div></div> | <div><div>° ' "</div><div>0 41 00</div></div> <div><div>° ' "</div><div>39 31</div></div> <div><div>° ' "</div><div>37 57</div></div> <div><div>° ' "</div><div>36 16</div></div> <div><div>° ' "</div><div>34 28</div></div> | <div><div>° ' "</div><div>0 40 43</div></div> <div><div>° ' "</div><div>39 15</div></div> <div><div>° ' "</div><div>37 41</div></div> <div><div>° ' "</div><div>36 01</div></div> <div><div>° ' "</div><div>34 14</div></div> | <div><div>° ' "</div><div>0 14 26</div></div> <div><div>° ' "</div><div>15 40</div></div> <div><div>° ' "</div><div>16 54</div></div> <div><div>° ' "</div><div>18 07</div></div> <div><div>° ' "</div><div>19 19</div></div> | <div><div>° ' "</div><div>0 14 20</div></div> <div><div>° ' "</div><div>15 34</div></div> <div><div>° ' "</div><div>16 47</div></div> <div><div>° ' "</div><div>17 59</div></div> <div><div>° ' "</div><div>19 11</div></div> | <div><div>° ' "</div><div>0 14 14</div></div> <div><div>° ' "</div><div>15 28</div></div> <div><div>° ' "</div><div>16 40</div></div> <div><div>° ' "</div><div>17 52</div></div> <div><div>° ' "</div><div>19 03</div></div> | <div><div>° ' "</div><div>0 14 08</div></div> <div><div>° ' "</div><div>15 21</div></div> <div><div>° ' "</div><div>16 33</div></div> <div><div>° ' "</div><div>17 45</div></div> <div><div>° ' "</div><div>18 55</div></div> | <div><div>7 04.8</div></div> <div><div>10.8</div></div> <div><div>16.8</div></div> <div><div>22.8</div></div> <div><div>28.8</div></div>  |         |         |         |  |                               |
| <div><div>3 05.5</div></div> <div><div>11.5</div></div> <div><div>17.5</div></div> <div><div>23.4</div></div> <div><div>29.4</div></div> | <div><div>° ' "</div><div>0 34 00</div></div> <div><div>° ' "</div><div>33 02</div></div> <div><div>° ' "</div><div>32 03</div></div> <div><div>° ' "</div><div>31 02</div></div> <div><div>° ' "</div><div>30 01</div></div> | <div><div>° ' "</div><div>0 33 46</div></div> <div><div>° ' "</div><div>32 49</div></div> <div><div>° ' "</div><div>31 50</div></div> <div><div>° ' "</div><div>30 50</div></div> <div><div>° ' "</div><div>29 49</div></div> | <div><div>° ' "</div><div>0 33 33</div></div> <div><div>° ' "</div><div>32 36</div></div> <div><div>° ' "</div><div>31 37</div></div> <div><div>° ' "</div><div>30 38</div></div> <div><div>° ' "</div><div>29 37</div></div> | <div><div>° ' "</div><div>0 33 19</div></div> <div><div>° ' "</div><div>32 23</div></div> <div><div>° ' "</div><div>31 25</div></div> <div><div>° ' "</div><div>30 25</div></div> <div><div>° ' "</div><div>29 25</div></div> | <div><div>° ' "</div><div>0 20 30</div></div> <div><div>° ' "</div><div>21 41</div></div> <div><div>° ' "</div><div>22 50</div></div> <div><div>° ' "</div><div>23 59</div></div> <div><div>° ' "</div><div>25 06</div></div> | <div><div>° ' "</div><div>0 20 22</div></div> <div><div>° ' "</div><div>21 32</div></div> <div><div>° ' "</div><div>22 41</div></div> <div><div>° ' "</div><div>23 49</div></div> <div><div>° ' "</div><div>24 56</div></div> | <div><div>° ' "</div><div>0 20 13</div></div> <div><div>° ' "</div><div>21 23</div></div> <div><div>° ' "</div><div>22 31</div></div> <div><div>° ' "</div><div>23 39</div></div> <div><div>° ' "</div><div>24 46</div></div> | <div><div>° ' "</div><div>0 20 05</div></div> <div><div>° ' "</div><div>21 14</div></div> <div><div>° ' "</div><div>22 22</div></div> <div><div>° ' "</div><div>23 29</div></div> <div><div>° ' "</div><div>24 36</div></div> | <div><div>7 34.8</div></div> <div><div>40.7</div></div> <div><div>46.7</div></div> <div><div>52.7</div></div> <div><div>58.7</div></div>  |         |         |         |  |                               |
| <div><div>3 35.4</div></div> <div><div>41.4</div></div> <div><div>47.4</div></div> <div><div>53.4</div></div> <div><div>59.3</div></div> | <div><div>° ' "</div><div>0 28 58</div></div> <div><div>° ' "</div><div>27 53</div></div> <div><div>° ' "</div><div>26 48</div></div> <div><div>° ' "</div><div>25 41</div></div> <div><div>° ' "</div><div>24 34</div></div> | <div><div>° ' "</div><div>0 28 46</div></div> <div><div>° ' "</div><div>27 42</div></div> <div><div>° ' "</div><div>26 37</div></div> <div><div>° ' "</div><div>25 31</div></div> <div><div>° ' "</div><div>24 24</div></div> | <div><div>° ' "</div><div>0 28 34</div></div> <div><div>° ' "</div><div>27 31</div></div> <div><div>° ' "</div><div>26 27</div></div> <div><div>° ' "</div><div>25 21</div></div> <div><div>° ' "</div><div>24 14</div></div> | <div><div>° ' "</div><div>0 28 23</div></div> <div><div>° ' "</div><div>27 20</div></div> <div><div>° ' "</div><div>26 16</div></div> <div><div>° ' "</div><div>25 11</div></div> <div><div>° ' "</div><div>24 05</div></div> | <div><div>° ' "</div><div>0 26 13</div></div> <div><div>° ' "</div><div>27 18</div></div> <div><div>° ' "</div><div>28 23</div></div> <div><div>° ' "</div><div>29 26</div></div> <div><div>° ' "</div><div>30 28</div></div> | <div><div>° ' "</div><div>0 26 02</div></div> <div><div>° ' "</div><div>27 07</div></div> <div><div>° ' "</div><div>28 11</div></div> <div><div>° ' "</div><div>29 14</div></div> <div><div>° ' "</div><div>30 15</div></div> | <div><div>° ' "</div><div>0 25 51</div></div> <div><div>° ' "</div><div>26 56</div></div> <div><div>° ' "</div><div>28 00</div></div> <div><div>° ' "</div><div>29 02</div></div> <div><div>° ' "</div><div>30 03</div></div> | <div><div>° ' "</div><div>0 25 41</div></div> <div><div>° ' "</div><div>26 45</div></div> <div><div>° ' "</div><div>27 48</div></div> <div><div>° ' "</div><div>28 50</div></div> <div><div>° ' "</div><div>29 51</div></div> | <div><div>8 04.7</div></div> <div><div>10.7</div></div> <div><div>16.6</div></div> <div><div>22.6</div></div> <div><div>28.6</div></div>  |         |         |         |  |                               |
| <div><div>4 05.3</div></div> <div><div>11.3</div></div> <div><div>17.3</div></div> <div><div>23.3</div></div> <div><div>29.3</div></div> | <div><div>° ' "</div><div>0 23 25</div></div> <div><div>° ' "</div><div>22 16</div></div> <div><div>° ' "</div><div>21 05</div></div> <div><div>° ' "</div><div>19 54</div></div> <div><div>° ' "</div><div>18 42</div></div> | <div><div>° ' "</div><div>0 23 16</div></div> <div><div>° ' "</div><div>22 07</div></div> <div><div>° ' "</div><div>20 57</div></div> <div><div>° ' "</div><div>19 46</div></div> <div><div>° ' "</div><div>18 35</div></div> | <div><div>° ' "</div><div>0 23 07</div></div> <div><div>° ' "</div><div>21 58</div></div> <div><div>° ' "</div><div>20 49</div></div> <div><div>° ' "</div><div>19 38</div></div> <div><div>° ' "</div><div>18 27</div></div> | <div><div>° ' "</div><div>0 22 57</div></div> <div><div>° ' "</div><div>21 49</div></div> <div><div>° ' "</div><div>20 40</div></div> <div><div>° ' "</div><div>19 30</div></div> <div><div>° ' "</div><div>18 20</div></div> | <div><div>° ' "</div><div>0 31 28</div></div> <div><div>° ' "</div><div>32 28</div></div> <div><div>° ' "</div><div>33 26</div></div> <div><div>° ' "</div><div>34 23</div></div> <div><div>° ' "</div><div>35 18</div></div> | <div><div>° ' "</div><div>0 31 16</div></div> <div><div>° ' "</div><div>32 15</div></div> <div><div>° ' "</div><div>33 12</div></div> <div><div>° ' "</div><div>34 09</div></div> <div><div>° ' "</div><div>35 04</div></div> | <div><div>° ' "</div><div>0 31 03</div></div> <div><div>° ' "</div><div>32 02</div></div> <div><div>° ' "</div><div>32 59</div></div> <div><div>° ' "</div><div>33 55</div></div> <div><div>° ' "</div><div>34 49</div></div> | <div><div>° ' "</div><div>0 30 50</div></div> <div><div>° ' "</div><div>31 48</div></div> <div><div>° ' "</div><div>32 45</div></div> <div><div>° ' "</div><div>33 41</div></div> <div><div>° ' "</div><div>34 35</div></div> | <div><div>8 34.6</div></div> <div><div>40.6</div></div> <div><div>46.6</div></div> <div><div>52.5</div></div> <div><div>58.5</div></div>  |         |         |         |  |                               |
| <div><div>4 35.2</div></div> <div><div>41.2</div></div> <div><div>47.2</div></div> <div><div>53.2</div></div> <div><div>59.2</div></div> | <div><div>° ' "</div><div>0 17 29</div></div> <div><div>° ' "</div><div>16 16</div></div> <div><div>° ' "</div><div>15 01</div></div> <div><div>° ' "</div><div>13 47</div></div> <div><div>° ' "</div><div>12 31</div></div> | <div><div>° ' "</div><div>0 17 22</div></div> <div><div>° ' "</div><div>16 09</div></div> <div><div>° ' "</div><div>14 56</div></div> <div><div>° ' "</div><div>13 41</div></div> <div><div>° ' "</div><div>12 26</div></div> | <div><div>° ' "</div><div>0 17 15</div></div> <div><div>° ' "</div><div>16 03</div></div> <div><div>° ' "</div><div>14 50</div></div> <div><div>° ' "</div><div>13 36</div></div> <div><div>° ' "</div><div>12 21</div></div> | <div><div>° ' "</div><div>0 17 08</div></div> <div><div>° ' "</div><div>15 56</div></div> <div><div>° ' "</div><div>14 44</div></div> <div><div>° ' "</div><div>13 30</div></div> <div><div>° ' "</div><div>12 17</div></div> | <div><div>° ' "</div><div>0 37 04</div></div> <div><div>° ' "</div><div>38 44</div></div> <div><div>° ' "</div><div>40 18</div></div> <div><div>° ' "</div><div>41 46</div></div> <div><div>° ' "</div><div>43 06</div></div> | <div><div>° ' "</div><div>0 36 49</div></div> <div><div>° ' "</div><div>38 29</div></div> <div><div>° ' "</div><div>40 02</div></div> <div><div>° ' "</div><div>41 29</div></div> <div><div>° ' "</div><div>42 49</div></div> | <div><div>° ' "</div><div>0 36 34</div></div> <div><div>° ' "</div><div>38 13</div></div> <div><div>° ' "</div><div>39 46</div></div> <div><div>° ' "</div><div>41 12</div></div> <div><div>° ' "</div><div>42 31</div></div> | <div><div>° ' "</div><div>0 36 19</div></div> <div><div>° ' "</div><div>37 58</div></div> <div><div>° ' "</div><div>39 30</div></div> <div><div>° ' "</div><div>40 55</div></div> <div><div>° ' "</div><div>42 14</div></div> | <div><div>9 10.5</div></div> <div><div>22.5</div></div> <div><div>34.4</div></div> <div><div>46.4</div></div> <div><div>58.4</div></div>  |         |         |         |  |                               |
| <div><div>5 05.2</div></div> <div><div>11.1</div></div> <div><div>17.1</div></div> <div><div>23.1</div></div> <div><div>29.1</div></div> | <div><div>° ' "</div><div>0 11 15</div></div> <div><div>° ' "</div><div>09 59</div></div> <div><div>° ' "</div><div>08 42</div></div> <div><div>° ' "</div><div>07 25</div></div> <div><div>° ' "</div><div>06 08</div></div> | <div><div>° ' "</div><div>0 11 11</div></div> <div><div>° ' "</div><div>09 55</div></div> <div><div>° ' "</div><div>08 39</div></div> <div><div>° ' "</div><div>07 22</div></div> <div><div>° ' "</div><div>06 06</div></div> | <div><div>° ' "</div><div>0 11 07</div></div> <div><div>° ' "</div><div>09 51</div></div> <div><div>° ' "</div><div>08 36</div></div> <div><div>° ' "</div><div>07 20</div></div> <div><div>° ' "</div><div>06 03</div></div> | <div><div>° ' "</div><div>0 11 02</div></div> <div><div>° ' "</div><div>09 47</div></div> <div><div>° ' "</div><div>08 32</div></div> <div><div>° ' "</div><div>07 17</div></div> <div><div>° ' "</div><div>06 01</div></div> | <div><div>° ' "</div><div>0 44 20</div></div> <div><div>° ' "</div><div>45 26</div></div> <div><div>° ' "</div><div>46 25</div></div> <div><div>° ' "</div><div>47 16</div></div> <div><div>° ' "</div><div>48 00</div></div> | <div><div>° ' "</div><div>0 44 02</div></div> <div><div>° ' "</div><div>45 08</div></div> <div><div>° ' "</div><div>46 06</div></div> <div><div>° ' "</div><div>46 57</div></div> <div><div>° ' "</div><div>47 41</div></div> | <div><div>° ' "</div><div>0 43 44</div></div> <div><div>° ' "</div><div>44 49</div></div> <div><div>° ' "</div><div>45 47</div></div> <div><div>° ' "</div><div>46 38</div></div> <div><div>° ' "</div><div>47 21</div></div> | <div><div>° ' "</div><div>0 43 26</div></div> <div><div>° ' "</div><div>44 31</div></div> <div><div>° ' "</div><div>45 29</div></div> <div><div>° ' "</div><div>46 19</div></div> <div><div>° ' "</div><div>47 02</div></div> | <div><div>10 10.3</div></div> <div><div>22.3</div></div> <div><div>34.3</div></div> <div><div>46.2</div></div> <div><div>58.2</div></div> |         |         |         |  |                               |
| <div><div>5 35.1</div></div> <div><div>41.1</div></div> <div><div>47.0</div></div> <div><div>53.0</div></div> <div><div>57.4</div></div> |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                                                                                                               |                                                                                                                                           |         |         |         |  |                               |

## EXPLANATIONS FOR THE STELLAR OBSERVATIONS

The data in this Ephemeris are arranged for the surveying practice of the Bureau of Land Management; the methods are useful in any survey where field observations are to be made for the ascertainment of the direction of a line in terms of angular value referred to the true meridian at that place.

In most cases, data are available as to the approximate latitude and longitude of the observing station, and preliminary determinations are made for the meridian and watch correction in terms of local mean time. The observations of the stars then follow on an observing program arranged for what is needed, and to suit the time of year, the latitude of the station, and other conditions that are factors.

A complete and well balanced stellar observing program will include: (1) the meridian passage of one star for time and latitude; (2) Polaris for azimuth and latitude; and (3) two well placed stars, one easterly and one westerly, both for azimuth, and one or both for time. The necessary verifications are thus accomplished. Instrumental uncertainties in the vertical angle readings are made apparent by this plan, and are compensated by taking the means of offsetting values. An observation may be made to verify only one or two values when the remainder are already well determined.

There are six stellar observing periods: (1) late afternoon, daylight; (2) early evening, twilight; (3) later p. m., after dark, illumination required; (4) after midnight, ditto; (5) early morning, twilight; and (6) after sunrise, daylight. The stars to be observed are chosen after deciding upon the observing period, and making the selection according to the desired position in hour angle and declination.

The time of a star's transit is to be reduced from the tabulated value for the Greenwich meridian to the longitude of the station; this is 10 seconds of time for each 15° (or one hour) of longitude, subtracted for west longitude (see table of Sidereal Conversions, page 27); this will give the correct local mean time at the moment of the star's meridian passage. The next step is to anticipate the probable local mean time of each observation, and the star's hour angle at that moment, to the east or to the west of the meridian.

The setting positions for the instrument in vertical angle ( $v$ ) and in horizontal angle ( $A$ ) are computed on the basis of the assumed hour angle ( $t$ ), the star's declination ( $\delta$ ), and the known or approximate latitude ( $\phi$ ). This is done to secure a setting that is sufficiently accurate to bring the star within the field of the telescope, especially if the observation is to be by daylight, or twilight; less accuracy is needed just for the star's identification if the observation is to be made during starlight. The preliminary computations may be made with 4-place tables. The true values are obtained by reduction of the observations. The reductions for stellar observations are similar to the methods applicable to observations of the sun, and employ the same equations.

In all stellar observations, the true vertical angle ( $h$ ) is equal to the observed vertical angle ( $v$ ) minus the refraction ( $r$ ) in zenith distance; there is no correction for parallax. In observations of the sun, the true vertical angle ( $h$ ) is equal to ( $v$ ) minus ( $r$ ) plus parallax; see table, page 25.

In observations of the sun, the meridian passage and the hour angle ( $t$ ) are in apparent solar time. The equation of time is applied to give the watch correction in terms of local mean time.

In observations of a star, the hour angle ( $t$ ) is in terms of a sidereal rate; a subtraction of 10 seconds per hour will give the equivalent mean time hour angle. (Sidereal Conversions, page 27).

The following equations are regarded as the most useful for the methods stated above:

On the meridian, the vertical angle:  $h = 90^\circ - \phi \pm \delta$ ; (or)  $\phi = 90^\circ - h \pm \delta$

At any hour angle:  $\sin h = \cos t \cos \phi \cos \delta + \sin \phi \sin \delta$

$$: \cos t = \frac{\sin h}{\cos \phi \cos \delta} - \tan \phi \tan \delta$$

$$: \cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$$

The product " $\sin \phi \sin \delta$ " and the fraction " $\frac{\sin \delta}{\cos \phi \cos h}$ " are negative for south declinations.

The product " $\cos t \cos \phi \cos \delta$ " is negative for hour angles exceeding six hours or 90°.

The product " $\tan \phi \tan \delta$ " is subtracted for north declinations; added for south declinations.

If the result for " $\cos A$ " is  $\begin{cases} \text{positive} \\ \text{negative} \end{cases}$  the horizontal angle counts from the  $\begin{cases} \text{north.} \\ \text{south.} \end{cases}$

If the result for " $\cos t$ " is  $\begin{cases} \text{positive} \\ \text{negative} \end{cases}$  the hour angle is  $\begin{cases} \text{less} \\ \text{more} \end{cases}$  than six hours or 90°.

By a stellar equal-altitude observation, the meridian is determined as the mean of two direction-pointings; the latitude is not required; there are no corrections as to declination. A mean of the watch readings at the moment of each observation is equivalent to a reading at the time of the star's meridian passage. The latitude may be reduced from the maximum vertical angle at meridian passage.

The equations as written and explained above are applicable for the northern latitudes; suitable transpositions are required for observations in the southern latitudes.

MEAN REFRACTIONS IN ZENITH DISTANCE AND SUN'S PARALLAX IN ALTITUDE  
Bar. : 29.6 ins.      Temp. : 50° F.

| Apparent<br>Altitude                                                                                                                                | Refraction | Sun's<br>Par. | Apparent<br>Altitude | Refraction                                                                                                   | Sun's<br>Par. | Apparent<br>Altitude | Refraction | Sun's<br>Par. |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|----------------------|--------------------------------------------------------------------------------------------------------------|---------------|----------------------|------------|---------------|
| ° ' "                                                                                                                                               | ' "        | "             | ° ' "                | ' "                                                                                                          | "             | °                    | ' "        | "             |
| 7 30                                                                                                                                                | 6 53       | 8.8           | 12 0                 | 4 25                                                                                                         | 8.7           | 25                   | 2 3        | 8.1           |
| 7 40                                                                                                                                                | 6 45       | 8.8           | 12 30                | 4 15                                                                                                         | 8.7           | 26                   | 1 58       | 8.0           |
| 7 50                                                                                                                                                | 6 37       | 8.8           | 13 0                 | 4 5                                                                                                          | 8.7           | 27                   | 1 53       | 7.9           |
| 8 0                                                                                                                                                 | 6 30       | 8.8           | 13 30                | 3 56                                                                                                         | 8.7           | 28                   | 1 48       | 7.9           |
| 8 10                                                                                                                                                | 6 22       | 8.8           | 14 0                 | 3 47                                                                                                         | 8.6           | 29                   | 1 44       | 7.8           |
| 8 20                                                                                                                                                | 6 15       | 8.8           | 14 30                | 3 39                                                                                                         | 8.6           | 30                   | 1 40       | 7.7           |
| 8 30                                                                                                                                                | 6 8        | 8.8           | 15 0                 | 3 32                                                                                                         | 8.6           | 32                   | 1 32       | 7.6           |
| 8 40                                                                                                                                                | 6 2        | 8.8           | 15 30                | 3 25                                                                                                         | 8.6           | 34                   | 1 25       | 7.4           |
| 8 50                                                                                                                                                | 5 55       | 8.8           | 16 0                 | 3 19                                                                                                         | 8.6           | 36                   | 1 19       | 7.2           |
| 9 0                                                                                                                                                 | 5 49       | 8.8           | 16 30                | 3 13                                                                                                         | 8.5           | 38                   | 1 14       | 7.0           |
| 9 10                                                                                                                                                | 5 43       | 8.8           | 17 0                 | 3 7                                                                                                          | 8.5           | 40                   | 1 9        | 6.8           |
| 9 20                                                                                                                                                | 5 38       | 8.8           | 17 30                | 3 1                                                                                                          | 8.5           | 42                   | 1 4        | 6.6           |
| 9 30                                                                                                                                                | 5 32       | 8.8           | 18 0                 | 2 56                                                                                                         | 8.5           | 44                   | 1 0        | 6.4           |
| 9 40                                                                                                                                                | 5 26       | 8.8           | 18 30                | 2 51                                                                                                         | 8.4           | 46                   | 0 56       | 6.2           |
| 9 50                                                                                                                                                | 5 21       | 8.8           | 19 0                 | 2 46                                                                                                         | 8.4           | 48                   | 0 52       | 6.0           |
| 10 0                                                                                                                                                | 5 16       | 8.8           | 19 30                | 2 42                                                                                                         | 8.4           | 50                   | 0 48       | 5.7           |
| 10 20                                                                                                                                               | 5 6        | 8.8           | 20 0                 | 2 37                                                                                                         | 8.4           | 55                   | 0 40       | 5.1           |
| 10 40                                                                                                                                               | 4 57       | 8.7           | 21 0                 | 2 29                                                                                                         | 8.3           | 60                   | 0 33       | 4.4           |
| 11 0                                                                                                                                                | 4 48       | 8.7           | 22 0                 | 2 22                                                                                                         | 8.2           | 65                   | 0 27       | 3.8           |
| 11 20                                                                                                                                               | 4 40       | 8.7           | 23 0                 | 2 15                                                                                                         | 8.2           | 70                   | 0 21       | 3.0           |
| 11 40                                                                                                                                               | 4 32       | 8.7           | 24 0                 | 2 9                                                                                                          | 8.1           | 80                   | 0 10       | 1.5           |
| 12 0                                                                                                                                                | 4 25       | 8.7           | 25 0                 | 2 3                                                                                                          | 8.1           | 90                   | 0 0        | 0.0           |
| Apparent altitude (observed vertical angle) : v<br>Sun's true altitude : h = v - refraction + parallax<br>Star's true altitude : h = v - refraction |            |               |                      | True refraction : mean refraction x coefficient for<br>barometric pressure x coefficient<br>for temperature. |               |                      |            |               |

COEFFICIENTS TO APPLY TO MEAN REFRACTIONS FOR VARIATIONS IN BAROMETER AND TEMPERATURE

| Barome-<br>ter<br>(Ins.) | Eleva-<br>tion<br>above<br>sea level<br>(Feet) | Coeffi-<br>cient | Barome-<br>ter<br>(Ins.) | Eleva-<br>tion<br>above<br>sea level<br>(Feet) | Coeffi-<br>cient | Barome-<br>ter<br>(Ins.) | Eleva-<br>tion<br>above<br>sea level<br>(Feet) | Coeffi-<br>cient | Temper-<br>ature<br>(Fahr.) | Coeffi-<br>cient |
|--------------------------|------------------------------------------------|------------------|--------------------------|------------------------------------------------|------------------|--------------------------|------------------------------------------------|------------------|-----------------------------|------------------|
| 30.5                     | -451                                           | 1.03             | 27.2                     | 2,670                                          | 0.92             | 23.6                     | 6,538                                          | 0.80             | -10°                        | 1.13             |
| 30.2                     | -181                                           | 1.02             | 26.9                     | 2,972                                          | .91              | 23.3                     | 6,887                                          | .79              | 0°                          | 1.11             |
| 30.0                     | 00                                             | 1.01             | 26.6                     | 3,277                                          | .90              | 23.0                     | 7,239                                          | .78              | +10°                        | 1.08             |
| 29.9                     | + 91                                           | 1.01             | 26.3                     | 3,586                                          | .89              | 22.7                     | 7,597                                          | .77              | 20°                         | 1.06             |
| 29.6                     | 366                                            | 1.00             | 26.0                     | 3,899                                          | .88              | 22.4                     | 7,960                                          | .76              | 30°                         | 1.04             |
| 29.3                     | 643                                            | .99              | 25.7                     | 4,215                                          | .87              | 22.1                     | 8,327                                          | .75              | 40°                         | 1.02             |
| 29.0                     | 924                                            | .98              | 25.4                     | 4,535                                          | .86              | 21.8                     | 8,700                                          | .74              | 50°                         | 1.00             |
| 28.7                     | 1,207                                          | .97              | 25.1                     | 4,859                                          | .85              | 21.5                     | 9,077                                          | .73              | 60°                         | .98              |
| 28.4                     | 1,493                                          | .96              | 24.8                     | 5,186                                          | .84              | 21.2                     | 9,460                                          | .72              | 70°                         | .96              |
| 28.1                     | 1,783                                          | .95              | 24.5                     | 5,518                                          | .83              | 20.9                     | 9,848                                          | .71              | 80°                         | .94              |
| 27.8                     | 2,075                                          | .94              | 24.2                     | 5,854                                          | .82              | 20.6                     | 10,242                                         | .70              | 90°                         | .93              |
| 27.5                     | 2,371                                          | .93              | 23.9                     | 6,194                                          | .81              | 20.3                     | 10,642                                         | .69              | 100°                        | .91              |
| 27.2                     | 2,670                                          | .92              | 23.6                     | 6,538                                          | .80              | 20.0                     | 11,047                                         | .68              | +110°                       | .90              |

26  
CONVERSION OF TIME TO ARC

| Min-<br>utes | Hours |       |       |       |       |       |        |        |        |        |        |        |        |
|--------------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|
|              | 0     | 1     | 2     | 3     | 4     | 5     | 6      | 7      | 8      | 9      | 10     | 11     | 12     |
| 0            | 0 00  | 15 00 | 30 00 | 45 00 | 60 00 | 75 00 | 90 00  | 105 00 | 120 00 | 135 00 | 150 00 | 165 00 | 180 00 |
| 1            | 0 15  | 15 15 | 30 15 | 45 15 | 60 15 | 75 15 | 90 15  | 105 15 | 120 15 | 135 15 | 150 15 | 165 15 | 180 15 |
| 2            | 0 30  | 15 30 | 30 30 | 45 30 | 60 30 | 75 30 | 90 30  | 105 30 | 120 30 | 135 30 | 150 30 | 165 30 | 180 30 |
| 3            | 0 45  | 15 45 | 30 45 | 45 45 | 60 45 | 75 45 | 90 45  | 105 45 | 120 45 | 135 45 | 150 45 | 165 45 | 180 45 |
| 4            | 1 00  | 16 00 | 31 00 | 46 00 | 61 00 | 76 00 | 91 00  | 106 00 | 121 00 | 136 00 | 151 00 | 166 00 | 181 00 |
| 5            | 1 15  | 16 15 | 31 15 | 46 15 | 61 15 | 76 15 | 91 15  | 106 15 | 121 15 | 136 15 | 151 15 | 166 15 | 181 15 |
| 6            | 1 30  | 16 30 | 31 30 | 46 30 | 61 30 | 76 30 | 91 30  | 106 30 | 121 30 | 136 30 | 151 30 | 166 30 | 181 30 |
| 7            | 1 45  | 16 45 | 31 45 | 46 45 | 61 45 | 76 45 | 91 45  | 106 45 | 121 45 | 136 45 | 151 45 | 166 45 | 181 45 |
| 8            | 2 00  | 17 00 | 32 00 | 47 00 | 62 00 | 77 00 | 92 00  | 107 00 | 122 00 | 137 00 | 152 00 | 167 00 | 182 00 |
| 9            | 2 15  | 17 15 | 32 15 | 47 15 | 62 15 | 77 15 | 92 15  | 107 15 | 122 15 | 137 15 | 152 15 | 167 15 | 182 15 |
| 10           | 2 30  | 17 30 | 32 30 | 47 30 | 62 30 | 77 30 | 92 30  | 107 30 | 122 30 | 137 30 | 152 30 | 167 30 | 182 30 |
| 11           | 2 45  | 17 45 | 32 45 | 47 45 | 62 45 | 77 45 | 92 45  | 107 45 | 122 45 | 137 45 | 152 45 | 167 45 | 182 45 |
| 12           | 3 00  | 18 00 | 33 00 | 48 00 | 63 00 | 78 00 | 93 00  | 108 00 | 123 00 | 138 00 | 153 00 | 168 00 | 183 00 |
| 13           | 3 15  | 18 15 | 33 15 | 48 15 | 63 15 | 78 15 | 93 15  | 108 15 | 123 15 | 138 15 | 153 15 | 168 15 | 183 15 |
| 14           | 3 30  | 18 30 | 33 30 | 48 30 | 63 30 | 78 30 | 93 30  | 108 30 | 123 30 | 138 30 | 153 30 | 168 30 | 183 30 |
| 15           | 3 45  | 18 45 | 33 45 | 48 45 | 63 45 | 78 45 | 93 45  | 108 45 | 123 45 | 138 45 | 153 45 | 168 45 | 183 45 |
| 16           | 4 00  | 19 00 | 34 00 | 49 00 | 64 00 | 79 00 | 94 00  | 109 00 | 124 00 | 139 00 | 154 00 | 169 00 | 184 00 |
| 17           | 4 15  | 19 15 | 34 15 | 49 15 | 64 15 | 79 15 | 94 15  | 109 15 | 124 15 | 139 15 | 154 15 | 169 15 | 184 15 |
| 18           | 4 30  | 19 30 | 34 30 | 49 30 | 64 30 | 79 30 | 94 30  | 109 30 | 124 30 | 139 30 | 154 30 | 169 30 | 184 30 |
| 19           | 4 45  | 19 45 | 34 45 | 49 45 | 64 45 | 79 45 | 94 45  | 109 45 | 124 45 | 139 45 | 154 45 | 169 45 | 184 45 |
| 20           | 5 00  | 20 00 | 35 00 | 50 00 | 65 00 | 80 00 | 95 00  | 110 00 | 125 00 | 140 00 | 155 00 | 170 00 | 185 00 |
| 21           | 5 15  | 20 15 | 35 15 | 50 15 | 65 15 | 80 15 | 95 15  | 110 15 | 125 15 | 140 15 | 155 15 | 170 15 | 185 15 |
| 22           | 5 30  | 20 30 | 35 30 | 50 30 | 65 30 | 80 30 | 95 30  | 110 30 | 125 30 | 140 30 | 155 30 | 170 30 | 185 30 |
| 23           | 5 45  | 20 45 | 35 45 | 50 45 | 65 45 | 80 45 | 95 45  | 110 45 | 125 45 | 140 45 | 155 45 | 170 45 | 185 45 |
| 24           | 6 00  | 21 00 | 36 00 | 51 00 | 66 00 | 81 00 | 96 00  | 111 00 | 126 00 | 141 00 | 156 00 | 171 00 | 186 00 |
| 25           | 6 15  | 21 15 | 36 15 | 51 15 | 66 15 | 81 15 | 96 15  | 111 15 | 126 15 | 141 15 | 156 15 | 171 15 | 186 15 |
| 26           | 6 30  | 21 30 | 36 30 | 51 30 | 66 30 | 81 30 | 96 30  | 111 30 | 126 30 | 141 30 | 156 30 | 171 30 | 186 30 |
| 27           | 6 45  | 21 45 | 36 45 | 51 45 | 66 45 | 81 45 | 96 45  | 111 45 | 126 45 | 141 45 | 156 45 | 171 45 | 186 45 |
| 28           | 7 00  | 22 00 | 37 00 | 52 00 | 67 00 | 82 00 | 97 00  | 112 00 | 127 00 | 142 00 | 157 00 | 172 00 | 187 00 |
| 29           | 7 15  | 22 15 | 37 15 | 52 15 | 67 15 | 82 15 | 97 15  | 112 15 | 127 15 | 142 15 | 157 15 | 172 15 | 187 15 |
| 30           | 7 30  | 22 30 | 37 30 | 52 30 | 67 30 | 82 30 | 97 30  | 112 30 | 127 30 | 142 30 | 157 30 | 172 30 | 187 30 |
| 31           | 7 45  | 22 45 | 37 45 | 52 45 | 67 45 | 82 45 | 97 45  | 112 45 | 127 45 | 142 45 | 157 45 | 172 45 | 187 45 |
| 32           | 8 00  | 23 00 | 38 00 | 53 00 | 68 00 | 83 00 | 98 00  | 113 00 | 128 00 | 143 00 | 158 00 | 173 00 | 188 00 |
| 33           | 8 15  | 23 15 | 38 15 | 53 15 | 68 15 | 83 15 | 98 15  | 113 15 | 128 15 | 143 15 | 158 15 | 173 15 | 188 15 |
| 34           | 8 30  | 23 30 | 38 30 | 53 30 | 68 30 | 83 30 | 98 30  | 113 30 | 128 30 | 143 30 | 158 30 | 173 30 | 188 30 |
| 35           | 8 45  | 23 45 | 38 45 | 53 45 | 68 45 | 83 45 | 98 45  | 113 45 | 128 45 | 143 45 | 158 45 | 173 45 | 188 45 |
| 36           | 9 00  | 24 00 | 39 00 | 54 00 | 69 00 | 84 00 | 99 00  | 114 00 | 129 00 | 144 00 | 159 00 | 174 00 | 189 00 |
| 37           | 9 15  | 24 15 | 39 15 | 54 15 | 69 15 | 84 15 | 99 15  | 114 15 | 129 15 | 144 15 | 159 15 | 174 15 | 189 15 |
| 38           | 9 30  | 24 30 | 39 30 | 54 30 | 69 30 | 84 30 | 99 30  | 114 30 | 129 30 | 144 30 | 159 30 | 174 30 | 189 30 |
| 39           | 9 45  | 24 45 | 39 45 | 54 45 | 69 45 | 84 45 | 99 45  | 114 45 | 129 45 | 144 45 | 159 45 | 174 45 | 189 45 |
| 40           | 10 00 | 25 00 | 40 00 | 55 00 | 70 00 | 85 00 | 100 00 | 115 00 | 130 00 | 145 00 | 160 00 | 175 00 | 190 00 |
| 41           | 10 15 | 25 15 | 40 15 | 55 15 | 70 15 | 85 15 | 100 15 | 115 15 | 130 15 | 145 15 | 160 15 | 175 15 | 190 15 |
| 42           | 10 30 | 25 30 | 40 30 | 55 30 | 70 30 | 85 30 | 100 30 | 115 30 | 130 30 | 145 30 | 160 30 | 175 30 | 190 30 |
| 43           | 10 45 | 25 45 | 40 45 | 55 45 | 70 45 | 85 45 | 100 45 | 115 45 | 130 45 | 145 45 | 160 45 | 175 45 | 190 45 |
| 44           | 11 00 | 26 00 | 41 00 | 56 00 | 71 00 | 86 00 | 101 00 | 116 00 | 131 00 | 146 00 | 161 00 | 176 00 | 191 00 |
| 45           | 11 15 | 26 15 | 41 15 | 56 15 | 71 15 | 86 15 | 101 15 | 116 15 | 131 15 | 146 15 | 161 15 | 176 15 | 191 15 |
| 46           | 11 30 | 26 30 | 41 30 | 56 30 | 71 30 | 86 30 | 101 30 | 116 30 | 131 30 | 146 30 | 161 30 | 176 30 | 191 30 |
| 47           | 11 45 | 26 45 | 41 45 | 56 45 | 71 45 | 86 45 | 101 45 | 116 45 | 131 45 | 146 45 | 161 45 | 176 45 | 191 45 |
| 48           | 12 00 | 27 00 | 42 00 | 57 00 | 72 00 | 87 00 | 102 00 | 117 00 | 132 00 | 147 00 | 162 00 | 177 00 | 192 00 |
| 49           | 12 15 | 27 15 | 42 15 | 57 15 | 72 15 | 87 15 | 102 15 | 117 15 | 132 15 | 147 15 | 162 15 | 177 15 | 192 15 |
| 50           | 12 30 | 27 30 | 42 30 | 57 30 | 72 30 | 87 30 | 102 30 | 117 30 | 132 30 | 147 30 | 162 30 | 177 30 | 192 30 |
| 51           | 12 45 | 27 45 | 42 45 | 57 45 | 72 45 | 87 45 | 102 45 | 117 45 | 132 45 | 147 45 | 162 45 | 177 45 | 192 45 |
| 52           | 13 00 | 28 00 | 43 00 | 58 00 | 73 00 | 88 00 | 103 00 | 118 00 | 133 00 | 148 00 | 163 00 | 178 00 | 193 00 |
| 53           | 13 15 | 28 15 | 43 15 | 58 15 | 73 15 | 88 15 | 103 15 | 118 15 | 133 15 | 148 15 | 163 15 | 178 15 | 193 15 |
| 54           | 13 30 | 28 30 | 43 30 | 58 30 | 73 30 | 88 30 | 103 30 | 118 30 | 133 30 | 148 30 | 163 30 | 178 30 | 193 30 |
| 55           | 13 45 | 28 45 | 43 45 | 58 45 | 73 45 | 88 45 | 103 45 | 118 45 | 133 45 | 148 45 | 163 45 | 178 45 | 193 45 |
| 56           | 14 00 | 29 00 | 44 00 | 59 00 | 74 00 | 89 00 | 104 00 | 119 00 | 134 00 | 149 00 | 164 00 | 179 00 | 194 00 |
| 57           | 14 15 | 29 15 | 44 15 | 59 15 | 74 15 | 89 15 | 104 15 | 119 15 | 134 15 | 149 15 | 164 15 | 179 15 | 194 15 |
| 58           | 14 30 | 29 30 | 44 30 | 59 30 | 74 30 | 89 30 | 104 30 | 119 30 | 134 30 | 149 30 | 164 30 | 179 30 | 194 30 |
| 59           | 14 45 | 29 45 | 44 45 | 59 45 | 74 45 | 89 45 | 104 45 | 119 45 | 134 45 | 149 45 | 164 45 | 179 45 | 194 45 |
| 60           | 15 00 | 30 00 | 45 00 | 60 00 | 75 00 | 90 00 | 105 00 | 120 00 | 135 00 | 150 00 | 165 00 | 180 00 | 195 00 |

Note : To convert seconds of time , use the first column for the number of seconds and the second column for the converted value in minutes and seconds of arc ; for example 33 seconds of time = 8'15" in arc .

Degrees of arc convert to hours and minutes of time ; minutes of arc convert to minutes and seconds of time . See right hand column for conversion of seconds of arc to seconds of time .

### SIDEREAL CONVERSIONS

|                                 |                                                                                                                                                                                                       |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sidereal into mean solar time : | To be subtracted from a sidereal time interval :<br>Argument, hours and minutes of sidereal interval .                                                                                                |
| Mean solar into sidereal time : | To be added to a mean time interval :<br>Argument, hours and minutes of mean time interval .                                                                                                          |
| For any stellar observation :   | Amount to be subtracted from the Greenwich mean time<br>of transit or elongation to obtain local mean time :<br>Argument, longitude west from Greenwich ; add for<br>longitudes east from Greenwich . |

FOR FINDING THE VERTICAL AND HORIZONTAL ANGLES OF A STAR  
Natural Sines, Cosines, and Tangents

| For<br>sin<br>tan | tan   | sin   | For<br>cos<br>only | For<br>sin<br>tan | tan   | sin   | For<br>cos<br>only | For<br>sin<br>tan | tan    | sin   | For<br>cos<br>only |
|-------------------|-------|-------|--------------------|-------------------|-------|-------|--------------------|-------------------|--------|-------|--------------------|
| 0°00'             | .0000 | .0000 | 90°00'             | 15°00'            | .2679 | .2588 | 75°00'             | 30°00'            | .5774  | .5000 | 60°00'             |
| 15'               | .0044 | .0044 | 45'                | 15'               | .2726 | .2630 | 45'                | 15'               | .5832  | .5038 | 45'                |
| 30'               | .0087 | .0087 | 30'                | 30'               | .2773 | .2672 | 30'                | 30'               | .5890  | .5075 | 30'                |
| 45'               | .0131 | .0131 | 15'                | 45'               | .2820 | .2714 | 15'                | 45'               | .5949  | .5113 | 15'                |
| 1°00'             | .0175 | .0175 | 89°00'             | 16°00'            | .2867 | .2756 | 74°00'             | 31°00'            | .6009  | .5150 | 59°00'             |
| 15'               | .0218 | .0218 | 45'                | 15'               | .2915 | .2798 | 45'                | 15'               | .6068  | .5188 | 45'                |
| 30'               | .0262 | .0262 | 30'                | 30'               | .2962 | .2840 | 30'                | 30'               | .6128  | .5225 | 30'                |
| 45'               | .0306 | .0305 | 15'                | 45'               | .3010 | .2882 | 15'                | 45'               | .6188  | .5262 | 15'                |
| 2°00'             | .0349 | .0349 | 88°00'             | 17°00'            | .3057 | .2924 | 73°00'             | 32°00'            | .6249  | .5299 | 58°00'             |
| 15'               | .0393 | .0393 | 45'                | 15'               | .3105 | .2965 | 45'                | 15'               | .6310  | .5336 | 45'                |
| 30'               | .0437 | .0436 | 30'                | 30'               | .3153 | .3007 | 30'                | 30'               | .6371  | .5373 | 30'                |
| 45'               | .0480 | .0480 | 15'                | 45'               | .3201 | .3049 | 15'                | 45'               | .6432  | .5410 | 15'                |
| 3°00'             | .0524 | .0523 | 87°00'             | 18°00'            | .3249 | .3090 | 72°00'             | 33°00'            | .6494  | .5446 | 57°00'             |
| 15'               | .0568 | .0567 | 45'                | 15'               | .3298 | .3132 | 45'                | 15'               | .6556  | .5483 | 45'                |
| 30'               | .0612 | .0610 | 30'                | 30'               | .3346 | .3173 | 30'                | 30'               | .6619  | .5519 | 30'                |
| 45'               | .0655 | .0654 | 15'                | 45'               | .3395 | .3214 | 15'                | 45'               | .6682  | .5556 | 15'                |
| 4°00'             | .0699 | .0698 | 86°00'             | 19°00'            | .3443 | .3256 | 71°00'             | 34°00'            | .6745  | .5592 | 56°00'             |
| 15'               | .0743 | .0741 | 45'                | 15'               | .3492 | .3297 | 45'                | 15'               | .6809  | .5628 | 45'                |
| 30'               | .0787 | .0785 | 30'                | 30'               | .3541 | .3338 | 30'                | 30'               | .6873  | .5664 | 30'                |
| 45'               | .0831 | .0828 | 15'                | 45'               | .3590 | .3379 | 15'                | 45'               | .6937  | .5700 | 15'                |
| 5°00'             | .0875 | .0872 | 85°00'             | 20°00'            | .3640 | .3420 | 70°00'             | 35°00'            | .7002  | .5736 | 55°00'             |
| 15'               | .0919 | .0915 | 45'                | 15'               | .3689 | .3461 | 45'                | 15'               | .7067  | .5771 | 45'                |
| 30'               | .0963 | .0958 | 30'                | 30'               | .3739 | .3502 | 30'                | 30'               | .7133  | .5807 | 30'                |
| 45'               | .1007 | .1002 | 15'                | 45'               | .3789 | .3543 | 15'                | 45'               | .7199  | .5842 | 15'                |
| 6°00'             | .1051 | .1045 | 84°00'             | 21°00'            | .3839 | .3584 | 69°00'             | 36°00'            | .7265  | .5878 | 54°00'             |
| 15'               | .1095 | .1089 | 45'                | 15'               | .3889 | .3624 | 45'                | 15'               | .7332  | .5913 | 45'                |
| 30'               | .1139 | .1132 | 30'                | 30'               | .3939 | .3665 | 30'                | 30'               | .7400  | .5948 | 30'                |
| 45'               | .1184 | .1175 | 15'                | 45'               | .3990 | .3706 | 15'                | 45'               | .7467  | .5983 | 15'                |
| 7°00'             | .1228 | .1219 | 83°00'             | 22°00'            | .4040 | .3746 | 68°00'             | 37°00'            | .7536  | .6018 | 53°00'             |
| 15'               | .1272 | .1262 | 45'                | 15'               | .4091 | .3786 | 45'                | 15'               | .7604  | .6053 | 45'                |
| 30'               | .1317 | .1305 | 30'                | 30'               | .4142 | .3827 | 30'                | 30'               | .7673  | .6088 | 30'                |
| 45'               | .1361 | .1349 | 15'                | 45'               | .4193 | .3867 | 15'                | 45'               | .7743  | .6122 | 15'                |
| 8°00'             | .1405 | .1392 | 82°00'             | 23°00'            | .4245 | .3907 | 67°00'             | 38°00'            | .7813  | .6157 | 52°00'             |
| 15'               | .1450 | .1435 | 45'                | 15'               | .4296 | .3947 | 45'                | 15'               | .7883  | .6191 | 45'                |
| 30'               | .1495 | .1478 | 30'                | 30'               | .4348 | .3987 | 30'                | 30'               | .7954  | .6225 | 30'                |
| 45'               | .1539 | .1521 | 15'                | 45'               | .4400 | .4027 | 15'                | 45'               | .8026  | .6259 | 15'                |
| 9°00'             | .1584 | .1564 | 81°00'             | 24°00'            | .4452 | .4067 | 66°00'             | 39°00'            | .8098  | .6293 | 51°00'             |
| 15'               | .1629 | .1607 | 45'                | 15'               | .4505 | .4107 | 45'                | 15'               | .8170  | .6327 | 45'                |
| 30'               | .1673 | .1650 | 30'                | 30'               | .4557 | .4147 | 30'                | 30'               | .8243  | .6361 | 30'                |
| 45'               | .1718 | .1693 | 15'                | 45'               | .4610 | .4187 | 15'                | 45'               | .8317  | .6394 | 15'                |
| 10°00'            | .1763 | .1736 | 80°00'             | 25°00'            | .4663 | .4226 | 65°00'             | 40°00'            | .8391  | .6428 | 50°00'             |
| 15'               | .1808 | .1779 | 45'                | 15'               | .4716 | .4266 | 45'                | 15'               | .8466  | .6461 | 45'                |
| 30'               | .1853 | .1822 | 30'                | 30'               | .4770 | .4305 | 30'                | 30'               | .8541  | .6494 | 30'                |
| 45'               | .1899 | .1865 | 15'                | 45'               | .4823 | .4344 | 15'                | 45'               | .8617  | .6528 | 15'                |
| 11°00'            | .1944 | .1908 | 79°00'             | 26°00'            | .4877 | .4384 | 64°00'             | 41°00'            | .8693  | .6561 | 49°00'             |
| 15'               | .1989 | .1951 | 45'                | 15'               | .4931 | .4423 | 45'                | 15'               | .8770  | .6593 | 45'                |
| 30'               | .2035 | .1994 | 30'                | 30'               | .4986 | .4462 | 30'                | 30'               | .8847  | .6626 | 30'                |
| 45'               | .2080 | .2036 | 15'                | 45'               | .5040 | .4501 | 15'                | 45'               | .8925  | .6659 | 15'                |
| 12°00'            | .2126 | .2079 | 78°00'             | 27°00'            | .5095 | .4540 | 63°00'             | 42°00'            | .9004  | .6691 | 48°00'             |
| 15'               | .2171 | .2122 | 45'                | 15'               | .5150 | .4579 | 45'                | 15'               | .9083  | .6724 | 45'                |
| 30'               | .2217 | .2164 | 30'                | 30'               | .5206 | .4617 | 30'                | 30'               | .9163  | .6756 | 30'                |
| 45'               | .2263 | .2207 | 15'                | 45'               | .5261 | .4656 | 15'                | 45'               | .9244  | .6788 | 15'                |
| 13°00'            | .2309 | .2250 | 77°00'             | 28°00'            | .5317 | .4695 | 62°00'             | 43°00'            | .9325  | .6820 | 47°00'             |
| 15'               | .2355 | .2292 | 45'                | 15'               | .5373 | .4733 | 45'                | 15'               | .9407  | .6852 | 45'                |
| 30'               | .2401 | .2334 | 30'                | 30'               | .5430 | .4772 | 30'                | 30'               | .9490  | .6884 | 30'                |
| 45'               | .2447 | .2377 | 15'                | 45'               | .5486 | .4810 | 15'                | 45'               | .9573  | .6915 | 15'                |
| 14°00'            | .2493 | .2419 | 76°00'             | 29°00'            | .5543 | .4848 | 61°00'             | 44°00'            | .9657  | .6947 | 46°00'             |
| 15'               | .2540 | .2462 | 45'                | 15'               | .5600 | .4886 | 45'                | 15'               | .9742  | .6978 | 45'                |
| 30'               | .2586 | .2504 | 30'                | 30'               | .5658 | .4924 | 30'                | 30'               | .9827  | .7009 | 30'                |
| 45'               | .2633 | .2546 | 15'                | 45'               | .5715 | .4962 | 15'                | 45'               | .9913  | .7040 | 15'                |
| 15°00'            | .2679 | .2588 | 75°00'             | 30°00'            | .5774 | .5000 | 60°00'             | 45°00'            | 1.0000 | .7071 | 45°00'             |
| For<br>sin<br>tan | tan   | cos   | For<br>cos<br>only | For<br>sin<br>tan | tan   | cos   | For<br>cos<br>only | For<br>sin<br>tan | tan    | cos   | For<br>cos<br>only |

On the meridian, the vertical angle:  $h = 90^\circ - \phi \pm \delta$

At any hour angle:  $\sin h = \cos t \cos \phi \cos \delta + \sin \phi \sin \delta$

The product: "sin  $\phi$  sin  $\delta$ " is negative for south declinations.

The product: "cos  $t$  cos  $\phi$  cos  $\delta$ " is negative for hour angles exceeding six hours or  $90^\circ$ .

FOR FINDING THE VERTICAL AND HORIZONTAL ANGLES OF A STAR  
Natural Sines, Cosines, and Tangents

| For<br>sin<br>tan | tan    | sin       | For<br>cos<br>only | For<br>sin<br>tan | tan    | sin       | For<br>cos<br>only | For<br>sin | sin    | For<br>cos<br>only |
|-------------------|--------|-----------|--------------------|-------------------|--------|-----------|--------------------|------------|--------|--------------------|
| 45°00'            | 1.0000 | 88 .7071  | 31 45°00'          | 60°00'            | 1.7321 | 175 .8660 | 22 30°00'          | 75°00'     | .9659  | 11 15°00'          |
| 15'               | 1.0088 | 88 .7102  | 31 45'             | 15'               | 1.7496 | 179 .8682 | 22 45'             | 15'        | .9670  | 11 45'             |
| 30'               | 1.0176 | 89 .7133  | 30 30'             | 30'               | 1.7675 | 181 .8704 | 21 30'             | 30'        | .9681  | 11 30'             |
| 45'               | 1.0265 | 90 .7163  | 30 15'             | 45'               | 1.7856 | 184 .8725 | 21 15'             | 45'        | .9692  | 11 15'             |
| 46°00'            | 1.0355 | 91 .7193  | 31 44°00'          | 61°00'            | 1.8040 | 188 .8746 | 21 29°00'          | 76°00'     | .9703  | 10 14°00'          |
| 15'               | 1.0446 | 92 .7224  | 31 45'             | 15'               | 1.8228 | 190 .8767 | 21 45'             | 15'        | .9713  | 10 45'             |
| 30'               | 1.0538 | 92 .7254  | 30 30'             | 30'               | 1.8418 | 193 .8788 | 21 30'             | 30'        | .9724  | 10 30'             |
| 45'               | 1.0630 | 94 .7284  | 30 15'             | 45'               | 1.8611 | 196 .8809 | 20 15'             | 45'        | .9734  | 10 15'             |
| 47°00'            | 1.0724 | 94 .7314  | 29 43°00'          | 62°00'            | 1.8807 | 200 .8829 | 21 28°00'          | 77°00'     | .9744  | 9 13°00'           |
| 15'               | 1.0818 | 95 .7343  | 29 45'             | 15'               | 1.9007 | 203 .8850 | 21 45'             | 15'        | .9753  | 9 45'              |
| 30'               | 1.0913 | 96 .7373  | 29 30'             | 30'               | 1.9210 | 206 .8870 | 20 30'             | 30'        | .9763  | 9 30'              |
| 45'               | 1.1009 | 97 .7402  | 29 15'             | 45'               | 1.9416 | 210 .8890 | 20 15'             | 45'        | .9772  | 9 15'              |
| 48°00'            | 1.1106 | 98 .7431  | 30 42°00'          | 63°00'            | 1.9626 | 214 .8910 | 20 27°00'          | 78°00'     | .9781  | 9 12°00'           |
| 15'               | 1.1204 | 99 .7461  | 29 45'             | 15'               | 1.9840 | 217 .8930 | 19 45'             | 15'        | .9790  | 9 45'              |
| 30'               | 1.1303 | 99 .7490  | 28 30'             | 30'               | 2.0057 | 221 .8949 | 19 30'             | 30'        | .9799  | 9 30'              |
| 45'               | 1.1403 | 100 .7518 | 28 15'             | 45'               | 2.0278 | 225 .8969 | 19 15'             | 45'        | .9808  | 8 15'              |
| 49°00'            | 1.1504 | 102 .7547 | 28 41°00'          | 64°00'            | 2.0503 | 229 .8988 | 19 26°00'          | 79°00'     | .9816  | 9 11°00'           |
| 15'               | 1.1606 | 102 .7576 | 28 45'             | 15'               | 2.0732 | 233 .9007 | 19 45'             | 15'        | .9825  | 8 45'              |
| 30'               | 1.1708 | 104 .7604 | 28 30'             | 30'               | 2.0965 | 238 .9026 | 19 30'             | 30'        | .9833  | 7 30'              |
| 45'               | 1.1812 | 106 .7632 | 28 15'             | 45'               | 2.1203 | 242 .9045 | 18 15'             | 45'        | .9840  | 8 15'              |
| 50°00'            | 1.1918 | 106 .7660 | 28 40°00'          | 65°00'            | 2.1445 | 247 .9063 | 18 25°00'          | 80°00'     | .9848  | 8 10°00'           |
| 15'               | 1.2024 | 107 .7688 | 28 45'             | 15'               | 2.1692 | 251 .9081 | 19 45'             | 15'        | .9856  | 7 45'              |
| 30'               | 1.2131 | 108 .7716 | 28 30'             | 30'               | 2.1943 | 256 .9100 | 18 30'             | 30'        | .9863  | 7 30'              |
| 45'               | 1.2239 | 110 .7744 | 27 15'             | 45'               | 2.2199 | 261 .9118 | 17 15'             | 45'        | .9870  | 7 15'              |
| 51°00'            | 1.2349 | 111 .7771 | 28 39°00'          | 66°00'            | 2.2460 | 267 .9135 | 18 24°00'          | 81°00'     | .9877  | 7 9°00'            |
| 15'               | 1.2460 | 112 .7799 | 27 45'             | 15'               | 2.2727 | 271 .9153 | 18 45'             | 15'        | .9884  | 7 45'              |
| 30'               | 1.2572 | 113 .7826 | 27 30'             | 30'               | 2.2998 | 278 .9171 | 18 30'             | 30'        | .9890  | 6 30'              |
| 45'               | 1.2685 | 114 .7853 | 27 15'             | 45'               | 2.3276 | 283 .9188 | 17 15'             | 45'        | .9897  | 7 15'              |
| 52°00'            | 1.2799 | 116 .7880 | 27 38°00'          | 67°00'            | 2.3559 | 288 .9205 | 17 23°00'          | 82°00'     | .9903  | 6 8°00'            |
| 15'               | 1.2915 | 117 .7907 | 27 45'             | 15'               | 2.3847 | 295 .9222 | 17 45'             | 15'        | .9909  | 6 45'              |
| 30'               | 1.3032 | 119 .7934 | 26 30'             | 30'               | 2.4142 | 299 .9239 | 17 30'             | 30'        | .9914  | 5 30'              |
| 45'               | 1.3151 | 119 .7960 | 26 15'             | 45'               | 2.4443 | 301 .9255 | 16 15'             | 45'        | .9920  | 6 15'              |
| 53°00'            | 1.3270 | 122 .7986 | 27 37°00'          | 68°00'            | 2.4751 | 314 .9272 | 16 22°00'          | 83°00'     | .9925  | 6 7°00'            |
| 15'               | 1.3392 | 122 .8013 | 26 45'             | 15'               | 2.5065 | 321 .9288 | 16 45'             | 15'        | .9931  | 5 45'              |
| 30'               | 1.3514 | 124 .8039 | 25 30'             | 30'               | 2.5386 | 329 .9304 | 16 30'             | 30'        | .9936  | 5 30'              |
| 45'               | 1.3638 | 126 .8064 | 25 15'             | 45'               | 2.5715 | 336 .9320 | 16 15'             | 45'        | .9941  | 5 15'              |
| 54°00'            | 1.3764 | 127 .8090 | 26 36°00'          | 69°00'            | 2.6051 | 344 .9336 | 15 21°00'          | 84°00'     | .9945  | 5 6°00'            |
| 15'               | 1.3891 | 128 .8116 | 25 45'             | 15'               | 2.6395 | 351 .9351 | 16 45'             | 15'        | .9950  | 4 45'              |
| 30'               | 1.4019 | 131 .8141 | 25 30'             | 30'               | 2.6746 | 360 .9367 | 15 30'             | 30'        | .9954  | 4 30'              |
| 45'               | 1.4150 | 131 .8166 | 26 15'             | 45'               | 2.7106 | 369 .9382 | 15 15'             | 45'        | .9958  | 4 15'              |
| 55°00'            | 1.4281 | 134 .8192 | 24 35°00'          | 70°00'            | 2.7475 | 377 .9397 | 15 20°00'          | 85°00'     | .9962  | 4 5°00'            |
| 15'               | 1.4415 | 135 .8216 | 25 45'             | 15'               | 2.7852 | 387 .9412 | 14 45'             | 15'        | .9966  | 3 45'              |
| 30'               | 1.4550 | 137 .8241 | 25 30'             | 30'               | 2.8239 | 397 .9426 | 15 30'             | 30'        | .9969  | 3 30'              |
| 45'               | 1.4687 | 139 .8266 | 24 15'             | 45'               | 2.8636 | 406 .9441 | 14 15'             | 45'        | .9973  | 3 15'              |
| 56°00'            | 1.4826 | 140 .8290 | 25 34°00'          | 71°00'            | 2.9042 | 417 .9455 | 14 19°00'          | 86°00'     | .9976  | 3 4°00'            |
| 15'               | 1.4966 | 142 .8315 | 24 45'             | 15'               | 2.9459 | 428 .9469 | 14 45'             | 15'        | .9979  | 3 45'              |
| 30'               | 1.5108 | 145 .8339 | 24 30'             | 30'               | 2.9887 | 439 .9483 | 14 30'             | 30'        | .9981  | 2 30'              |
| 45'               | 1.5253 | 146 .8363 | 24 15'             | 45'               | 3.0326 | 451 .9497 | 14 15'             | 45'        | .9984  | 3 15'              |
| 57°00'            | 1.5399 | 148 .8387 | 23 33°00'          | 72°00'            | 3.0777 | 463 .9511 | 13 18°00'          | 87°00'     | .9986  | 2 3°00'            |
| 15'               | 1.5547 | 150 .8410 | 24 45'             | 15'               | 3.1240 | 476 .9524 | 13 45'             | 15'        | .9988  | 2 45'              |
| 30'               | 1.5697 | 152 .8434 | 23 30'             | 30'               | 3.1716 | 489 .9537 | 13 30'             | 30'        | .9990  | 2 30'              |
| 45'               | 1.5849 | 154 .8457 | 23 15'             | 45'               | 3.2205 | 504 .9550 | 13 15'             | 45'        | .9992  | 2 15'              |
| 58°00'            | 1.6003 | 157 .8480 | 24 32°00'          | 73°00'            | 3.2709 | 517 .9563 | 13 17°00'          | 88°00'     | .9994  | 1 2°00'            |
| 15'               | 1.6160 | 159 .8504 | 22 45'             | 15'               | 3.3226 | 533 .9576 | 12 45'             | 15'        | .9995  | 2 45'              |
| 30'               | 1.6319 | 160 .8526 | 23 30'             | 30'               | 3.3759 | 549 .9588 | 12 30'             | 30'        | .9997  | 1 30'              |
| 45'               | 1.6479 | 164 .8549 | 23 15'             | 45'               | 3.4308 | 566 .9600 | 13 15'             | 45'        | .9998  | 0 15'              |
| 59°00'            | 1.6643 | 165 .8572 | 22 31°00'          | 74°00'            | 3.4874 | 583 .9613 | 12 16°00'          | 89°00'     | .9998  | 1 1°00'            |
| 15'               | 1.6808 | 169 .8594 | 22 45'             | 15'               | 3.5457 | 602 .9625 | 11 45'             | 15'        | .9999  | 1 45'              |
| 30'               | 1.6977 | 170 .8616 | 22 30'             | 30'               | 3.6059 | 621 .9636 | 12 30'             | 30'        | 1.0000 | 0 30'              |
| 45'               | 1.7147 | 174 .8638 | 22 15'             | 45'               | 3.6680 | 641 .9648 | 11 15'             | 45'        | 1.0000 | 0 15'              |
| 60°00'            | 1.7321 | .8660     | 30°00'             | 75°00'            | 3.7321 | .9659     | 15°00'             | 90°00'     | 1.0000 | 0°00'              |
| For<br>sin<br>tan | tan    | cos       | For<br>cos<br>only | For<br>sin<br>tan | tan    | cos       | For<br>cos<br>only | For<br>sin | cos    | For<br>cos<br>only |

The horizontal angle may be found from the equation:  $\cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$

"Sin  $\delta$ " is negative for south declinations.

If the result for "cos A" is {positive} the horizontal angle counts from the {north.  
negative} south.

## PREPARING FOR THE OBSERVATIONS

The modern solar transit, as developed for surveying the public lands, affords a ready determination of the factors of time, latitude, and azimuth, which are the starting values employed in the stellar observations. The latter are designed to supply the desired refinements in the values, better than the limits of the solar unit. A carefully determined meridian is used in making the instrumental adjustments and tests, preliminary to the running of the lines, and the direction of the latter is verified at frequent intervals.

Since few solar transits are in general use, consideration is to be given to the preliminary steps to be taken when the factors of time, latitude, and azimuth are unknown, or are only roughly approximate. If nothing is to be assumed as known, or approximate, it is well to begin with the equal-altitude observation on the sun, or one of the known bright stars, by which the latitude, azimuth, and time may all be derived.

If the uncertainty in latitude is not more than 2' or 3', an altitude observation of the sun, or any known bright star, may be made, from which to derive preliminary values for time and azimuth, using the approximate latitude as the factor until its value can be suitably corrected. An observation of Polaris at elongation may be made without exact data as to the time or latitude.

An interpretation of the terms "approximate" and "rough" may be helpful in clarifying what is intended. These terms have been used with reference to the preliminary values for time, latitude, and azimuth, to be regarded as more or less reliable for the identification of a star by vertical and horizontal angles. For this purpose and for a starlight period, a rough estimate based upon incomplete data, employed with good judgment, may allow a fairly wide tolerance and yet be entirely acceptable for the identification of a star without the slightest doubt. However, if a daylight or twilight observing period is proposed the setting positions should be sufficiently good to bring the star within the middle-third of the telescope. The time of passage across the field is slightly more than 4 minutes.

Some practice in making the observations by starlight is needed, or will be helpful, before making the twilight or daylight observations, and for the latter it is desirable to prepare the data for several positions for the sequence of settings at intervals that will allow for the reading of angles and the instrumental reversals. Obviously, the twilight or daylight observation will depend very largely upon the clearness of the atmosphere.

In all cases the finding positions are for the identification of a star, and having served that purpose the observation proceeds with the required care in all detail. The arrangement of the data and the suggestions as to the observing plan are intended to simplify the steps. The methods for a well-balanced observing program are good for results within  $\pm 6$  seconds of time;  $\pm 15''$  in latitude and azimuth; for vernier readings to the nearest 30"; due care being given to the necessary refinements in the observing and in the reductions; these limits are with reference to the one-minute transit ordinarily supplied to the field parties.

The setting positions for the instrument, in vertical angle ( $v$  or  $h$  for this purpose), and in horizontal angle ( $A$ ) counting from the meridian (or from an approximate north and south line) are derived from the equations after having determined the hour angle ( $t$ ) for the anticipated moment for the observation.

The 4-place tables may be used to shorten the work, as being sufficient for the star's identification or finding.

Example.

Star: 6-10 1.1  
 $\alpha$  Tauri (Aldebaran)  
 $\delta$  :  $+16^\circ 28'$

$$\sin h = \cos t \cos \varphi \cos \delta + \sin \varphi \sin \delta$$

|                    | <u>cos</u> | <u>sin</u>       |
|--------------------|------------|------------------|
| $t = .330$         |            |                  |
| $\varphi = .816$   |            | .578             |
| $\delta = .959$    |            | <u>.283</u>      |
|                    | .2582      | .1636 (Products) |
|                    |            | <u>.2582</u>     |
| $\sin h =$         |            | .4218 (Sum)      |
| $h = 24^\circ 57'$ |            |                  |

| $\varphi$           | : Approximate latitude: $35^{\circ}18'$                                                                                                                                                                                                                                                                                                                                   |                         |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------|------------|------|--|------|--|------|--|------|--|------|-------|--|------------------|--|-------|-------------------------|
| $t$                 | : Anticipated hour angle: $4^h43^m (70^{\circ}45')$                                                                                                                                                                                                                                                                                                                       |                         |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
| $\cos A =$          | $\frac{\sin \delta}{\cos \varphi \cos h} - \tan \varphi \tan h$                                                                                                                                                                                                                                                                                                           |                         |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
|                     | <table> <tr> <th><u>cos</u></th> <th><u>sin</u></th> <th><u>tan</u></th> </tr> <tr> <td>.816</td> <td></td> <td>.708</td> </tr> <tr> <td></td> <td>.283</td> <td></td> </tr> <tr> <td>.907</td> <td></td> <td>.465</td> </tr> <tr> <td>.7401</td> <td></td> <td>.3292 (Products)</td> </tr> <tr> <td></td> <td>.3824</td> <td><u>.3824</u> (Fraction)</td> </tr> </table> | <u>cos</u>              | <u>sin</u> | <u>tan</u> | .816 |  | .708 |  | .283 |  | .907 |  | .465 | .7401 |  | .3292 (Products) |  | .3824 | <u>.3824</u> (Fraction) |
| <u>cos</u>          | <u>sin</u>                                                                                                                                                                                                                                                                                                                                                                | <u>tan</u>              |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
| .816                |                                                                                                                                                                                                                                                                                                                                                                           | .708                    |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
|                     | .283                                                                                                                                                                                                                                                                                                                                                                      |                         |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
| .907                |                                                                                                                                                                                                                                                                                                                                                                           | .465                    |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
| .7401               |                                                                                                                                                                                                                                                                                                                                                                           | .3292 (Products)        |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
|                     | .3824                                                                                                                                                                                                                                                                                                                                                                     | <u>.3824</u> (Fraction) |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
| $\cos A =$          | .0532 (Diff. + )                                                                                                                                                                                                                                                                                                                                                          |                         |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |
| $A = 86^{\circ}57'$ | (Counting from the north)                                                                                                                                                                                                                                                                                                                                                 |                         |            |            |      |  |      |  |      |  |      |  |      |       |  |                  |  |       |                         |

In general make each reading to the nearest third place, regarding the values as merely approximate. The results are good as finding positions, or for the star's identification. The true values are obtained by careful reduction of the observations.



# TAFI QMNI

THESE ARE THE FIRST TWO PAGES OF A MEMORANDUM IN WHICH THE  
 AUTHOR HAS SET OUT THE RESULTS OF HIS RESEARCH INTO THE  
 PROBLEM OF THE TAFI QMNI.

THE RESEARCH WAS DONE BY THE AUTHOR IN THE YEAR 1957  
 AND WAS DONE IN THE FOLLOWING MANNER: THE AUTHOR

TOOK A SERIES OF PHOTOGRAPHS OF THE TAFI QMNI  
 AND THEN MADE A SERIES OF MEASUREMENTS OF THE  
 DISTANCE BETWEEN THE TAFI QMNI AND THE

NEAREST POINT OF THE TAFI QMNI TO THE TAFI QMNI  
 AND THEN MADE A SERIES OF MEASUREMENTS OF THE

AREA OF THE TAFI QMNI AND THEN MADE A SERIES OF  
 MEASUREMENTS OF THE DISTANCE BETWEEN THE TAFI QMNI

AND THE TAFI QMNI AND THEN MADE A SERIES OF  
 MEASUREMENTS OF THE DISTANCE BETWEEN THE TAFI QMNI

AND THE TAFI QMNI AND THEN MADE A SERIES OF



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